JOURNAL OF

CHEMICAL EDUCATION

Published by the DIVISION OF CHEMICAL EDUCATION OF THE AMERICAN CHEMICAL SOCIETY

NOW READY

QUALITATIVE ANALYSIS

Using Semimicro Methods

E. S. GILREATH

Associate Professor of Chemistry, Washington and Lee University

288 pages, $4.25

An extremely teachable and well-balanced text presenting an integrated discussion of the concepts, theories, and laws relating to solutions. The aim of the book is to bridge the gap between general chemistry and physical chemistry by including a number of important topics that cannot be either omitted or adequately covered in these two over-crowded fields. Special emphasis is placed upon the properties of solutions of electrolytes. Wherever possible, there is an attempt to correlate the theoretical discussions with the laboratory procedures of qualitative analysis. The experimental section offers systematic schemes of analyses for the cations and anions.

FEATURES OF THE TEXT INCLUDE

- Departures in presentation. The separation and identification of the common metallic elements as carried out in the orthodox scheme of qualitative analysis were of such unconnected sequence as to discourage a logical development of the underlying theory of the particular steps within the procedures. This book retains a modified form of the original scheme of analysis, but the development of theory follows in an orderly manner with little regard to its immediate application to laboratory procedures.
- An unusually comprehensive treatment of complex ions is presented. This study includes the nature of the linkage between components in complex ions, the effect of ionic size and electronic structure upon the extent of hydration, and the effect of hydrated cations upon the pH of aqueous solutions. In addition, there is a comprehensive survey of the various possible types of complex ions and coordination compounds.
- Each chapter in the theoretical section is followed by problems, questions, or exercises, with special emphasis upon carefully-constructed and challenging problems. Many solved problems are provided in the text.

Send for a copy on approval

McGRAW-HILL BOOK COMPANY, Inc.

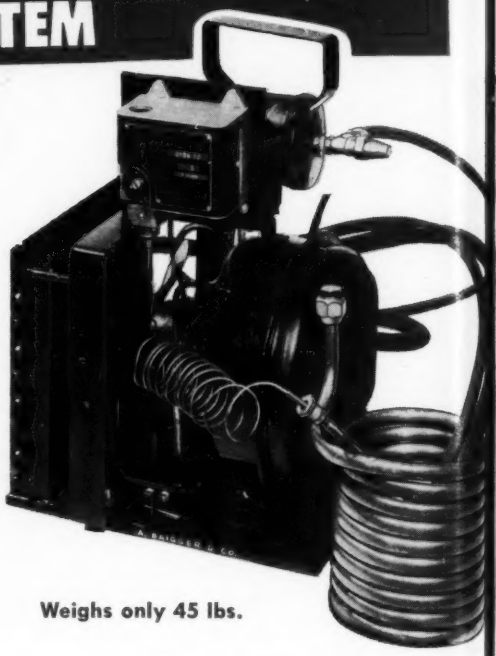
330 West 42nd Street New York 36, New York

daigger

Portable REFRIGERATION SYSTEM

carry the cold to the job!

- **Ready to plug-in and operate**
- **Thermostatic control ±2 deg. F.**
- **Simple, practical, adaptable**



Weighs only 45 lbs.

Carrying the "cold" to the job is now a practical reality with the "Mobil-Cold," the portable refrigerator unit, with thermostat control and mobile cooling coil. Weighing only forty-five pounds, it plugs into any 115 volt A. C. outlet, is virtually as simple to operate as a kitchen refrigerator and just as easy to service. Applicable to research and control procedures calling for temperatures below ambient, as in crystallization studies, melting point determinations, dry freezing, circulation of cooling media through refractometers polariscopes, sacharimeters, falling ball viscosimeters, jacketed conductivity cells; temperature conditioning of storage environment for unstable chemicals; cooling media for constant temperature baths; microscope freezing stages; cold "fingers" and traps for distillations.

Complete, ready to function. Comprises a ⅛ H.P. fan cooled, hermetically sealed compressor powered by a continuous duty motor, a portable copper cooling coil, 5″ dia. × 8″ high for placement where application dictates; a sensitive, adjustable thermostat to control desired temperature by governing compressor system; charging tank and valve system to permit several changes of the cooling coil without replenishing the Freon charge; flexible 8 ft. insulated hose to serve the cooling coil; all other necessary valves and fittings.

Cooling capacity. Operable from room temperature to 0 deg. F. Removes 790 Btu per hour at 20 deg. F., adequate for all normal laboratory bath-cooling operations. A five-gallon water bath can be cooled from room temperature to freezing in approximately two hours; one gallon of water from room temperature to 32 deg. F. in less than one-half hour. Program cooling and constant temperature work are facilitated by using "Mobil-Cold" with a mercury thermoregulator and suitable heater bank.

Practical, adjustable thermostat. Fully enclosed in metal housing with ½″ conduit opening. Snap-action switch actuated by hydraulic thermal element of copper capillary tubing, 8 ft. long. Differential adjustable from approximately 2 deg. to 10 deg.; factory set at 2 deg. Uniform differential at all points within the range. Thermostat unit may be mounted in any position. Sensing element has ¾″ water-tight fitting suitable for immersion duct mounting. Reference dial setting can be locked.

Servicing available everywhere. Compressor the most widely used in the refrigeration industry, representing highest level of development with respect economy, compactness, dependability. Compressor is a cooled, employing "Freon 12" refrigerant, powered by high-starting-torque motor.

Simplicity, portable mobility. Set thermostat the desired temperature, place cooling coil where desire turn on current. No pipe connections, no mechanical wor no disturbance of baths, vessels, containers. Additio lengths of insulated hose available to locate the cooling c remote from compressor. Extra large reserve gas supply a unique valve system permits modifications to a variety of us

DATA FOR ORDERING

JC10 Mobil-Cold Portable Unit, cooling capacity 790 BTU. Compl as described, *without metal cabinet.* Dimensions 13″ wide × 13 deep × 19″ to top of carrying handle. Cooling coil, 8″ high × dia. For operation on 110-120 volts A. C., 60 cycles. F.O.B. Chica ..... $275.

JC15 Mobil-Cold Portable Unit, *as above, but in steel cabinet,* on ea rolling casters. Cabinet has two ventilating panels; lifts off base unit for full exposure of mechanism to facilitate service or adjustm Cabinet finished in attractive, durable gray Hammerloid. 16″ w × 16″ deep × 22″ high. Weight 80 pounds. F.O.B. Chicago.. ..... $319.

Other models available. *Send for questionnaire get quotation on cooling units of larger capacity, with or wi out cabinets or equipped with special thermostatic compone cooling coils, heat exchangers, auxiliary baths, etc.*

A. DAIGGER & COMPANY

159 W. Kinzie Street • Chicago 10, Illinois

Since 1894

VOLUME 31

September, 1954

NUMBER 9

JOURNAL OF CHEMICAL EDUCATION

Published by the
DIVISION OF
CHEMICAL EDUCATION
OF THE
AMERICAN CHEMICAL
SOCIETY

OFFICERS

A. B. Garrett — *Chairman*
C. A. Vander Werf — *Chairman-elect*
G. W. Smith — *Secretary*
F. B. Dutton — *Treasurer*

NORRIS W. RAKESTRAW
Editor

Benjamin F. Gould
Advertising Mgr.

Phyllis Grant — *Asst. to the Ed.*
Harvey F. Mack — *Business Mgr.*
C. S. Fleck — *Asst. Business Mgr.*

BOARD OF PUBLICATION

G. W. Smith — A. B. Garrett
M. G. Mellon — W. F. Ehret
F. B. Dutton — P. W. West

ASSOCIATE EDITORS

William E. Cadbury, Jr.
Haverford College
Haverford, Pennsylvania

Laurence S. Foster
Watertown Arsenal, Massachusetts

W. F. Kieffer
College of Wooster

Kenneth A. Kobe
University of Texas

Henry M. Leicester
College of Physicians and Surgeons
of San Francisco

Ralph E. Oesper
University of Cincinnati

O. Rose Robertson
University of California
Los Angeles, Calif.

B. D. VanEvera
George Washington University
Washington, D. C.

Elbert C. Weaver
Phillips Academy
Andover, Mass.

BUSINESS & PUBLICATION
20th and Northampton Streets
Easton, Pennsylvania

EDITORIAL OFFICE
Scripps Institution
La Jolla, California

ADVERTISING OFFICE
500 Fifth Avenue
New York 36, N. Y.

The Abundance and Distribution of the Chemical Elements in the Earth's Crust, *Michael Fleischer* 446

Le Chatelier's Principle and the Equilibrium Constant, *Arild J. Miller* 455

What the Editors of the *Journal of the American Chemical Society* Expect of Authors, *Marshall Gates* 456

Ludwig Ebert, *Nelly Konopik* 458

Symposium on Recent Advances in Analytical Chemistry

The Reliability of Calculations Based Upon the Law of Chemical Equilibrium, *Donald D. DeFord* 460

Indeterminate Error Estimates from Small Groups of Replicates, *Ralph A. Johnson* 465

Organic Quantitative Analysis, *James S. Fritz* 468

The Japanese Chemical Literature, *Leo J. Stevens* 471

Nuclear Chemistry at Harvard, *Geoffrey Wilkinson, Richard M. Diamond, and Eugene G. Rochow* 474

A Sublimation Apparatus for Rapid Separations, *Lewis N. Pino and Winfield S. Zehrung III* 476

A Magnetic Model of Polyelectrolyte Interaction, *B. E. Conway* 477

Stimulating Interest in Laboratory Experiments, *Bernard M. Mitzner* 480

One More Periodic Table, *R. T. Sanderson* 481

Survey of Courses in Biochemistry, *Gordon H. Pritham* 482

Proceedings of the Pacific Southwest Association of Chemistry Teachers

Phytosynthesis: First Reactions, *Andrew A. Benson* 484

Entropy Calculations at Low Temperature, *George Calingaert* 487

Report of the New England Association of Chemistry Teachers

Chemical Problems Associated with the Development of Nuclear Reactors, *William F. Kieffer* 488

Chemical Education Book Exhibit List 48

Editor's Outlook 445
Out of the Editor's Basket 23
Letters to the Editor 495
Recent Books 496
Frontispiece—Ludwig Ebert 45
Advertisers' Index 87

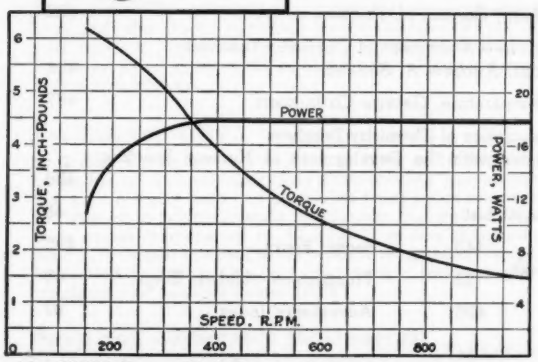
Subscription Price: Domestic $3.50 per year; Countries in Pan-American Union $3.50 per year; Canada $4.00; other countries $4.50. Issued monthly. Single copies of issues in current year, 50¢ each; all other single copies, one dollar. Foreign remittances must be accompanied by International Money Order.

No claims for copies of journals lost in the mails can be allowed unless such claims are received within sixty (60) days of the date of issue and no claims can be allowed for issues lost as a result of insufficient notice of change of address. Manuscripts for publication should be directed to the editor. Prospective authors are urged to avoid diffuse writing and to observe the forms outlined in our Notice to Authors of Papers as it appears on page 666 of the Dec. 1953 issue. Entered as second-class matter, January 31, 1924, at the Post Office at Easton, Pa., under the act of March 3, 1879. Accepted for mailing at special rate of postage provided for in Section 1103, Act of Oct. 3, 1917, authorized Jan. 31, 1924.

The JOURNAL OF CHEMICAL EDUCATION is the official organ of the Divisions of Chemical Education and History of Chemistry and incorporates the Report of the New England Association of Chemistry Teachers, and the Proceedings of the Pacific Southwest Association of Chemistry Teachers. It is indexed in the Education Index, Industrial Arts Index, and, in part, in the Quarterly Cumulative Index Medicus.

Copyright, 1954, by Division of Chemical Education, American Chemical Society

Left—Drive shaft parallel with face of cone insures high torque and constant speeds under varying load conditions. Speed is easily adjusted by merely turning the knurled knob at the top.



No. 18802 Cenco High Torque Motor Stirrer, 115 volts, 60 cycle AC.....$79.00
No. 18802H, same as above but with universal motor.....$96.00

8 Reasons Why cenco *High Torque* STIRRERS *DO A BETTER JOB—*

This unit is designed to handle a simple or critical stirring job with maximum efficiency. It's engineered and built for absolute dependability under the most exacting requirements. Light liquids or viscous . . . high or low speed . . . constant or varying consistency . . . whatever the job, it will do it the way you want it done . . . perfectly.

Here are a few of the reasons why:

- High torque at all speeds.
- Precise control of speed from 100 to 1300 rpm without reducing stirring effectiveness.
- Adequate power for stirring extremely viscous liquids.
- Fully enclosed cone drive protected from fumes, oil spattering, etc.
- Stainless steel parts resist corrosion.
- No variation of stirring speed though consistency of liquid may change greatly.
- Improved double-grip chuck provides tight clamping and perfect alignment of stirring rod.
- Finger-tip speed adjustment with indicator showing speed setting.

Cenco High Torque Stirrers are preferred by laboratory technicians all over the country. Order yours today. We'll make prompt shipment.

cenco

The most complete line of scientific instruments and laboratory supplies in the world

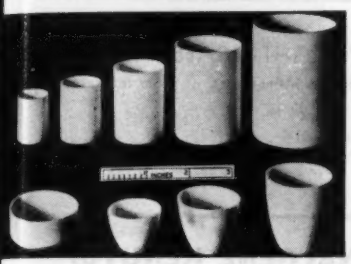
R.S.G.

CENTRAL SCIENTIFIC COMPANY
MAIN OFFICE — PLANT — CENCO INTERNATIONAL CIA.
1718-E IRVING PARK ROAD • CHICAGO 13, ILLINOIS
BRANCHES AND OFFICES — CHICAGO NEWARK BOSTON WASHINGTON DETROIT SAN FRANCISCO SANTA CLARA LOS ANGELES
CENTRAL SCIENTIFIC CO. OF CANADA, LTD. (and Hendry Division)
TORONTO MONTREAL VANCOUVER OTTAWA
REFINERY SUPPLY COMPANY — TULSA HOUSTON

Out of the Editor's Basket

New Sintered Alumina Crucibles

Laboratory crucibles in which almost all metals and their alloys can be melted without fear of contamination of the melt by the crucible have been introduced by Palo Laboratory Supplies, Inc. The crucibles, fabricated of Kearal sintered alumina, were made possible through the development of a special high density aluminum oxide ceramic material that can be fabricated in thin sections, and are available in a complete range of sizes.



The unusual resistance offered by Palo's new sintered alumina crucibles to the strongest reducing agents will be readily understood when it is remembered that alumina, in general, is one of the most chemically stable materials. Palo's new crucibles cannot be reduced, for example, by carbons and hydrocarbons at temperatures as high as 1700° C., and equal resistance is shown under the influence of hydrogen, at temperatures close to the 2050° C. melting point of alumina.

Full information and prices of the complete line of Palo sintered alumina crucibles are available from Palo Laboratory Supplies, Inc., 81 Reade St., New York 7, New York.

New Separatory Funnel

A new separatory funnel that requires no lubricants has been announced by the Kontes Glass Co.

The new funnel has an Ultramax Teflon valve developed by Fischer & Porter Co., Hatboro, Pennsylvania, that marks a sharp departure from conventional stopcocks. Because it uses no lubricants, materials heretofore sensitive to lubricants can now be handled with the Kontes funnel. Acids, alkalies, and other reagents will not cause the valve to stick, it was reported.

Without lubricants to dissolve, the firm noted, there is no troublesome leakage. The smaller funnels (30 to 125 ml.) are especially adaptable for centrifuging and the valve is so designed that it is completely locked during this process.

Prices and additional information are available from Kontes Glass Co., Vineland, New Jersey.

Acrylonitrile Chart

A comprehensive chart showing chemical methods for converting acrylonitrile into more than 100 derivatives is available from Monsanto Chemical Co., St. Louis 4, Missouri.

This 44- × 34-in. wall chart presents in sequential form the methods for the synthesis of acrylonitrile compounds according to three general classifications: cyanoethylation reactions, nitrile reactions, and olefinic reactions. In addition, the chart contains a literature summary of potential uses for 16 of the more important acrylonitrile derivatives.

Fast Neutron Counters

Radiation Counter Laboratories, Inc., Skokie, Illinois, announces a new line of single and multichambered directional and nondirectional fast neutron counters. These use Oak Ridge critical chamber sizes and have been designed to give good operating characteristics and ruggedness.

Counters of one, two, and three chambers are filled with pure methane gas to a pressure of 150 cm. Operating voltage is 2100 volts. Counters having more than three chambers are filled to a pressure of 13.2 cm. and operate at 1200 volts. Each chamber is lined with polyethylene and is separated from its neighbor by a brass spacer to reduce gamma pile-up effect. Standard models consist of 1,2,3,4, and 8 chambers, although models of up to 15 chambers are available. Designation of counters is RCL Mark 2 Models 201, 202,

Beauty COMES TO THE LAB SINK

contact your

Laboratory Furniture Manufacturer

or write direct to

Gone the drab brown of chemical stoneware with its rough salt-glazed surface—

Today's laboratory sink in gray-glazed cast chemical porcelain is as strikingly attractive in appearance as it is efficient in use. The smooth glazed surfaces clean as easily as a porcelain wash bowl. The inside corners are rounded smooth, no rough projections, no welded seams . . . correctly sloped for complete drainage.

Stronger by far than chemical stoneware, more resistant to chemicals, completely non-absorbent (even without glazing), these new gray-glazed chemical porcelain sinks match today's modern lab in both appearance and durability.

317-D

U. S. STONEWARE CO.
AKRON 9, OHIO

POLYETHYLENE WARE
FOR THE LABORATORY

NALGENE PIPET BASKET

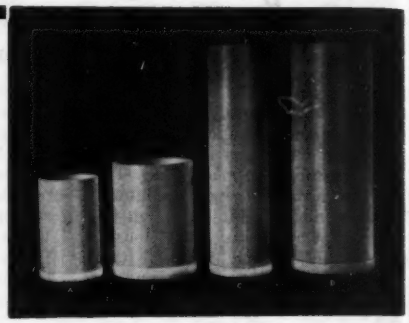
A basket of resilient, lightweight, chemically resistant polyethylene for handling pipets and other small glass items during soaking and washing.

A perforated screen is recessed ¾" into the base for complete drainage. Carrying handle of lightweight aluminum, completely sealed in polyethylene. All parts of thick polyethylene for rigidity and long life.

Cat. No. 83410—
Size B (Use with 6½ x 9" B Jar) ea. $15.50
Size D (Use with 6½ x 18" D Jar) ea. $16.50

Prevent Breakage and Accidents with

NALGENE PIPET JARS



UNBREAKABLE — LIGHT WEIGHT — SAFE — RESILIENT

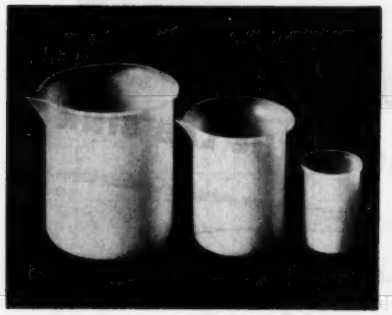
of unplasticized virgin polyethylene, chemically resistant, at room temperatures, to acids, alkalis, cleaning solutions and detergents.

Cat. No. 84918

Size A	(5" x 8")	ea. $9.00	Size D	(6½" x 18")	ea. $13.25
Size B	(6½" x 9")	ea. $10.50	Size E	(6½" x 18" to 27")	ea. $19.50
Size C	(5" x 18")	ea. $11.50	Size F	(6½" x 27" to 36")	ea. $24.50

NALGENE BEAKERS

Heavy Molded "Airothene"



Cat. No. 84910—

Cap. ml.	25	50	100	150
Price, ea.	.65	.90	1.05	1.30
Cap. ml.	**250**	**400**	**600**	**1000**
Price, ea.	$1.45	$1.85	$2.75	$4.00

Lots of 12 of a kind, less 10%
Lots of 48, assorted, less 20%

NALGENE CENTRIFUGE TUBES

Cat. No. 84919—
15 ml. cap. conical tube, ea. .50
50 ml. cap. round tube, ea. .55
(Fits standard centrifuge shields)

Less 10% in lots of 36. Less 15% in lots of 144, assorted.

NALGENE KENUTUF FUNNELS

Designed properly for chemical work with 60 degree angle for rapid filtering and outside rubbing to prevent airlock.

Cat. No. 84915

Diameter	Stem Length	Overall Length	Price ea.
1½"	1½"	2¼"	.20
2½"	1½"	3¾"	.35
3½"	1⅞"	5"	.60
4½"	2⅝"	6"	.90
5½"	3⅞"	8¼"	$1.25
6½"	4½"	9½"	$1.50
8½"	5"	11¾"	$2.40

Less 10% in doz. lots. Less 15% in lots of 36. Less 20% in lots of 144.

STANDARD SCIENTIFIC SUPPLY CORP.
34 West 4th Street • New York 12, N. Y.

ALL THE APPARATUS, EQUIPMENT, SUPPLIES CHEMICALS AND REAGENTS NEEDED TO RUN TODAY'S MODERN LABORATORIES.

03, 204, and 208, respectively, the last number of the series designating the number of chambers desired.

New Low Temperature Bath and Circulating System

Precision Scientific Co. has developed the "Lo-Temptrol," a low temperature bath and circulating system designed as a convenient means of reducing temperature rapidly and holding it at a precisely controlled point.

Equipped with a combination stirrer and pump, the "Lo-Temptrol" can be used as a low temperature bath or a portable pumping system for water and sewage tests, clinical and biochemical procedures, for viscosimeter tests, and for cooling condensers, refractometers and spectrophotometers.

The "Lo-Temptrol" bath is available in two sizes with two temperature ranges. The small, 15-gallon bath has a range from room to −30° C.; the large, 45-gallon bath from room to 0°C. A "Micro-Set" thermoregulator controls temperatures to ±0.1°C. near room temperature, to ±0.01°C. at low temperatures. Bath capacities are ample to permit simultaneous use as bath and circulating system, without affecting the sensitivity of control.

The "Lo-Temptrol" will circulate coolant—alcohol, ethylene glycol, or Prestone (or water for above freezing)—at the rate of three gallons per minute.

Data Sheet No. 11297 giving complete details is available from Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Illinois.

Centrifugal Mill

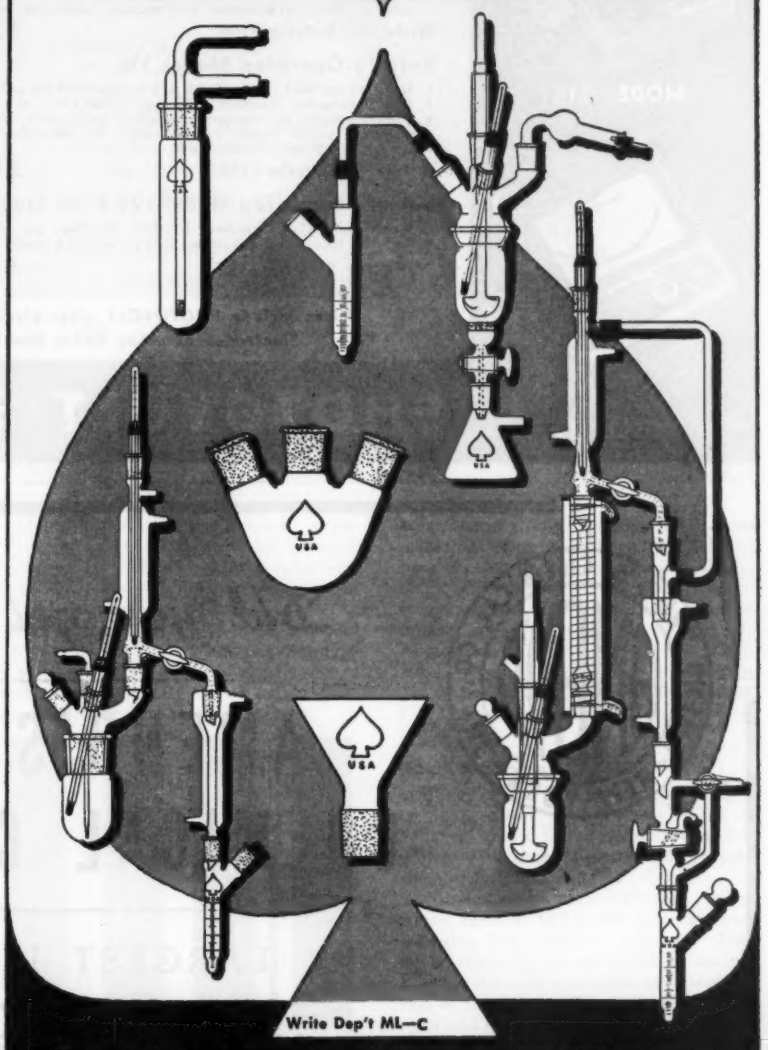
A new type centrifugal mill has been designed by E. H. Sargent & Co. for the analytical reduction of samples, particularly for the determination of oil content in small oil-bearing seeds. In tests this wet mill greatly reduced transfer operations with inherent sample loss, while extractions and solution processes occurred simultaneously with the milling of the sample.

The mill employs a capacitor motor which rotates at 1725 r. p. m. Samples

The New "MINI-LAB" Improved

CUSTOM-ENGINEERED ASSEMBLIES
AND COMPONENTS FOR
SMALL-SCALE LABORATORY WORK
NEW ASSEMBLIES MORE COMPONENTS
GREATER VERSATILITY INTERCHANGEABLE PARTS

SAVE TIME—MATERIALS—MONEY WITH "MINI-LAB"
NOW AVAILABLE WITH ♀ 14/20 JOINTS



Write Dep't ML—C

Illustrated above are a few of the many assemblies and components listed in the new "Mini-Lab" Brochure—we will be pleased to send your copy immediately upon request.

"Mini-Lab" is still available with ♀ 14/35 Joints for those who have been using and prefer them.

ACE GLASS INCORPORATED
VINELAND NEW JERSEY

PHOTOVOLT Electronic pH METERS

A complete line of pH meters incorporating modern electronic tubes and circuits, simple in operation and maintenance, featuring sealed amplifier plug-in units.

MODEL 115

Line-Operated Model 115

- Single range 0-14, scale length 4", accuracy 0.05 pH unit.
- Fully stabilized for wide range of line voltage fluctuations.
- Unprecedented in compactness and low price of only

Write for Bulletin #225 **$11[illegible]**

Line-Operated Model 110

- Single range 0-14, scale length 7", accuracy 0.02 pH unit.
- Available also with shielded compartment, with base board and carrying hood, with bottles and beakers, additional price $4[illegible]

Write for Bulletin #105 **$185.—**

MODEL·110

Battery-Operated Model 125

- Single range 0-14, scale length 5½", accuracy 0.03 pH unit.
- Only 3 batteries, standard radio type, 2,000 hours of service.
- Carrying frame for instrument, beakers, and bottles, price $20.—.
- Stabilized power supply unit available for alternative operation from 110 volt AC line, price $48.—.

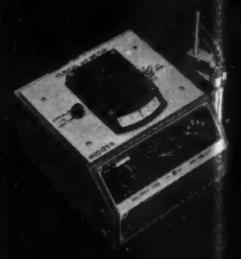
Write for Bulletin #118 **$145.—**

Battery-Operated Model 125-B for Blood pH

- Scale length 2¾", expanded five-fold for blood pH tests.
- Accuracy 0.01 in pH 6-8 range, 0.05 in pH 2-12 range.

Write for Bulletin #122 **$165.—**

MODEL 125



MODEL 125-B

Prices include PHOTOVOLT glass electrode and calomel electrode. Electrodes of other makes usable, adapters available.

PHOTOVOLT CORPORATION
95 MADISON AVENUE, N. Y. 16, N. Y.

AMEND DRUG & CHEMICAL CO., INC. — AMEND — NEW YORK

Did you get Yours?

AMEND'S NEW CHEMICAL CATALOG

LARGEST LISTING

MORE FROM ONE SOURCE

Catalog No. 54-C is available free on request.
Please use your firm or institution letterhead

AMEND DRUG & CHEMICAL CO., INC.
117-119 East 24th Street New York 10, N. Y.

y be ground to an approximate limit of
) mesh. Successful tests have been
de with sesame seed, flax seed, corn,
s, and tomatoes. For complete infor-
tion write for a copy of S.A.M., Volume
No. 2, Advertising Department, E. H.
rgent & Co., 4647 W. Foster Ave.,
icago 30, Illinois.

ctrifuges

Climaxing over 45 years of building elec-
centrifuges, both large and small, for
oratory work, Chicago Surgical &
ctrical Co., Divisions of Labline, Inc.,
nounces their new line of 1954 "Electri-
ges."

C.S.&E. "Electrifuges" are completely
ew and include such features as, modern
streamline cabinet with Formica top,
hich can be used as a working top; flush
ype safety catch; ball-bearing rubber-
overed casters; storage space for acces-
ories; built-in 6000 r. p. m. speed indi-
ator; 3-hour electric timer; electric
rake, eliminating old style hand or foot
rake; 1/3-h.-p. series wound motor;
all-bearing grease-sealed motor bearings
never requiring lubrication; safety switch
n cover, and Powerstat stepless speed
ontrol.

Over 30 different types of heads are
vailable. Cabinet is 37 in. high and
matches with regular laboratory furniture.
Designated as Model 10, the new C.S.&E.
"Electrifuge" is the newest in electric
entrifuges now available.

Catalogue No. 10, which gives complete
details may be had by writing to Chicago
Surgical & Electrical Co., Division of
Labline, Inc., 217 N. Desplaines St.,
Chicago 6, Illinois.

Black-Reading Mercury Gives Thermometers High Visibility

Quick, clear-reading, maximum-contrast
visibility of black-on-white is now avail-
able in mercury thermometers. Quiksite
black-reading thermometers, announced
this month by H-B Instrument Co., com-
bine the easy readability of a black-and-
white printed page with the inherent ad-
vantages of mercury-in-glass instruments.

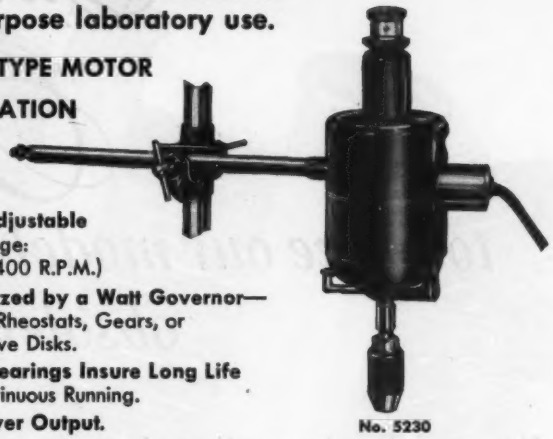
Watt-Governor Speed Controlled
LABORATORY STIRRER

Sparkless Electric Stirrer ideal for general purpose laboratory use.

INDUCTION TYPE MOTOR

QUIET OPERATION

LONG LIFE



- **Delicately Adjustable Speed Range: (200 to 1,400 R.P.M.)**
- **Speed Stabilized by a Watt Governor— Eliminates Rheostats, Gears, or Friction-Drive Disks.**
- **Thrust Ball Bearings Insure Long Life under Continuous Running.**
- **Uniform Power Output.**

No. 5230

No. 5230. NON-SPARKING MOTOR STIRRER.
60-cycle 110-volt A.C. Circuit. Each $43.50

No. 5230A. Similar to No. 5230 but for 220-volt, 60 cycle A.C. circuit. A "stepdown" transformer from 220 to 110 volts is provided in the line. Each $54.75

Manufacturers of Scientific Instruments and Laboratory Apparatus

W. M. WELCH SCIENTIFIC COMPANY
DIVISION OF W. M. WELCH MANUFACTURING COMPANY
ESTABLISHED 1880
1515 Sedgwick St., Dept. D-1, Chicago 10, Illinois, U.S.A.

Quiksite thermometers present a jet-black thread against a white background, nullifying the confusing exterior reflections which have formerly made mercury instruments difficult and slow to read. The value of maximum contrast of black and white is shown in the accompanying illustration, which compares the appearance of a mirror-like mercury thread and a Quiksite black-reflecting thread.

Detailed information on Quiksite and other H-B mercury instruments is contained in Catalog 19-A, available on request from H-B Instrument Co., American & Bristol Sts., Philadelphia 40, Pennsylvania.

Magnetic Stirring Bars

Magnetic stirring bars that consist of an Alnico type V cylindrical permanent magnet sealed in Kel-F are now obtainable. Kel-F, a noninflammable thermoplastic, suitable for use at temperatures from −200 to +200°C., is unaffected by prolonged exposure to strong and weak acids, including concentrated sulfuric, hydrofluoric, and hydrochloric acids, fuming nitric acid, aqua regia and other powerful oxidizing agents, concentrated alkalies, mineral oils, and most organic solvents. Three sizes of these stirring bars are offered. Further information, in Bulletin 118, is available from Arthur H. Thomas Co., 230 S. 7th St., Philadelphia 5, Pennsylvania.

New Chemicals Available

● Heavy water containing 9.5–10.5% of O^{18} concentrate has recently been announced by the Dajac Laboratories Division of Monomer-Polymer, Inc., Leominster, Massachusetts.

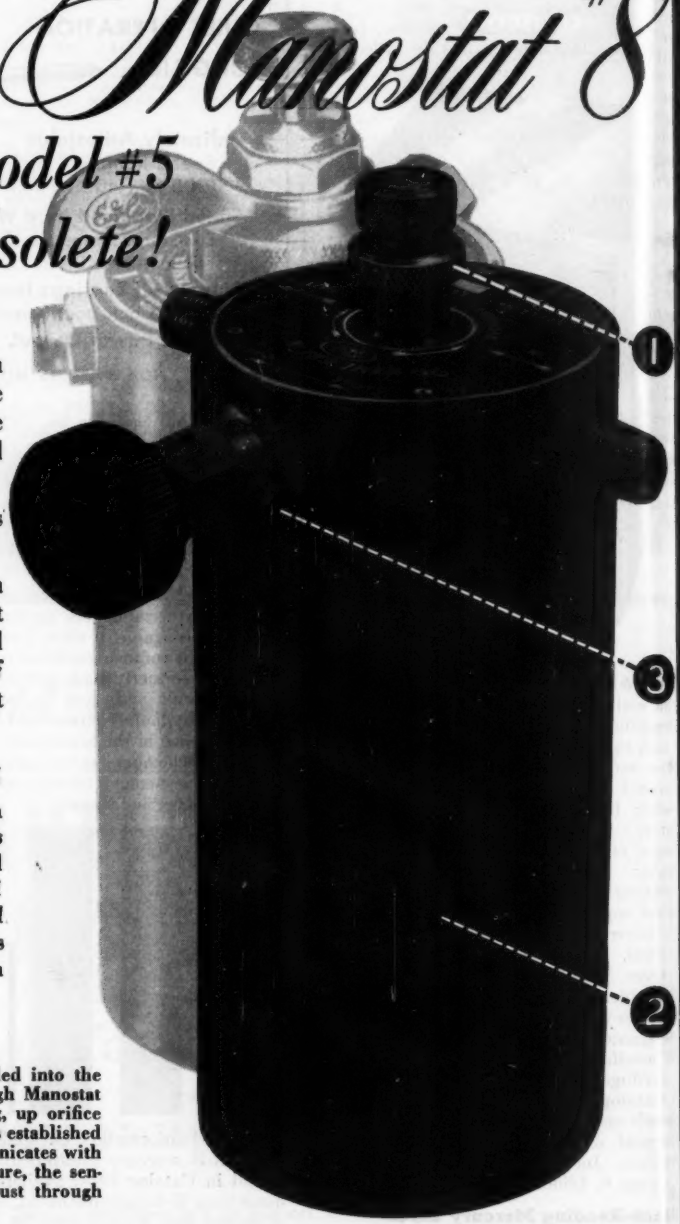
This heavy water is the most concentrated form of O^{18} water thus far made available for research purposes. Each lot of water has a certificate of analysis showing the mass spectrometer determination of the O^{17} and O^{18} content.

In addition, the Dajac Laboratories offers a custom preparation of O^{18} labeled compounds such as alcohols, ketones, and organic acids, as well as inorganic reagents such as sulfuric and nitric acids, and various alkalies and oxides.

In special cases, it is possible to offer the heavy water in a range of concentrations from 3% to 30% of O^{18} content.

These tagged compounds are potentially of great interest for research chemical, biological, and physiological studies. Full information regarding these products may be obtained by writing to the above address.

it took this new Cartesian Manostat #8 to make our model #5 obsolete!



For more than 4 years Cartesian Manostat No. 5 was regarded by many as the ultimate in providing automatic pressure and vacuum control simply, efficiently and economically.

Today this magnificent instrument is obsolete.

In its place—a vast improvement and a complete new design—is Cartesian Manostat No. 8. Years in the planning, this new model fulfills today's greater requirements of pressure control in the laboratory, pilot plant and industry.

these improvements obsolete model #5

Based on the principle of the Cartesian Diver, Model No. 8 is ❶ *greatly simplified in its operation.* You merely place this self-contained unit in your system—SET IT AND FORGET IT! ❷ It has an *anodized aluminum body.* ❸ *A needle valve by-pass replaces the stopcock.* It has high sensitivity, high capacity, and is corrosion resistant.

how it works

Gas from higher source of pressure than system is bled into the system at controlled rate. Portion of gas passes through Manostat into system; excess gas passes through orifice opening, up orifice tube, to source of lower pressure. Controlling pressure is established inside float. When pressure outside float, which communicates with system, becomes slightly higher than controlling pressure, the sensitive float will drop, and permit excess gas to exhaust through orifice, automatically maintaining desired pressure.

For complete information describing our line of Manostats including performance and operating data, write for our pressure control bulletin.

CARTESIAN MANOSTAT
MODEL NO. 8
PATENT 2,482,167
Complete with 3 interchangeable orifices and mercury
$79.50

The EMIL GREINER Co.
20-26 N. MOORE STREET NEW YORK 13, N.Y.

Just announced is a list of 13 additions to the group of some 3500 Eastman Organic Chemicals sold for research, analytical, and teaching purposes by Distillation Products Industries, Rochester 3, New York (Division of Eastman Kodak Company).

Included among the new items is 4,4′-Bis (2-amino-1-napthylazo)2,2′-stilbenedisulfonic Acid Disodium Salt; 4-Hydroxy-3-nitrobenzenearsonic Acid; 2-(*o*-Hydroxyphenyl)benzothiazole; Phthalaldehydic Acid; 4,4′-Biphenylenebis(3,3-dimethyl-1-triazene); 1-(4-Biphenylyl)-3,3-dimethyltriazene; Bromocyclopentane (Pract.); 2,5-Dihydroxy-*p*-benzenedisulfonic Acid Dipotassium Salt; 3,3′-Dimethoxy-1,4′-biphenyl Diisocyanate (Pract.); Dimethyl Nitroterephthalate; trans-1,4-Diphenyl-2-butene-1,4-dione (Pract.); Isatoic Anhydride; 5-Phenyl-2,4-pentadienoic Acid.

New Literature

● Detailed descriptions, technical and nontechnical, and suggested uses of Koppers "dbpc" antioxidant are contained in two new bulletins published by Koppers Co., Inc.

Technical Bulletin C-4-115 furnishes toxicological information, descriptions of chemical reactions, and commercial information on this product, which has been tested and proved effective as an antioxidant for fatty foods and hydrocarbon materials such as petroleum products, rubber, and plastics.

In the second bulletin, C-4-197, information in nontechnical language is furnished on the use of "dbpc" antioxidant in food, plastics, rubber, insulating oils, petroleum fuels, lubricants and waxes, and nonedible animal and vegetable oils.

Copies of either or both of these bulletins may be obtained from Koppers Co., Inc., Chemical Division, Koppers Building, Pittsburgh 19, Pennsylvania.

● A revised technical booklet which illustrates how Vinsol resin may be used to reduce the cost of phenol-formaldehyde resins is now available from Hercules Powder Co., Wilmington, Del. This booklet gives up-to-date information on Vinsol as an extender and reveals numerous ways in which it can be used. Vinsol resin is a dark colored, high-melting thermoplastic material. The phenolic nature of Vinsol makes it useful as a modifier and extender for phenol-formaldehyde resins, and distinguishes it from other rosinlike materials sometimes used as extenders for thermosetting resins.

The 32-page booklet includes sections on Vinsol-aldehyde condensates; solvent-blended Vinsol-phenolic resins; water-blended Vinsol-phenolic resins, and Vinsol-phenol-formaldehyde copolymers.

● A new two-page data sheet No. E-94(1) describing a students' calibrating unit for manual polarographic measurements, is now available from Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pennsylvania. Equipment for instruction in polarographic techniques is described, as well as specifications of the various related instruments. Also shown is a schematic diagram demonstrating a typical laboratory setup.

another New **NALGE** laboratory assistant!

POLYETHYLENE Centrifuge Tubes

WHAT could be more practical than these new Polyethylene Centrifuge Tubes? . . . clean, lightweight, resilient, acid and alkali-resistant and completely guaranteed to withstand the greatest centrifugal forces currently employed! Certainly these small, but all-important units prove that we are going all out to make our line of laboratory Polyethylene-ware the most complete anywhere. From these to 13-gallon carboys, to tubing, stopcocks, pipet jars, bottles . . . Nalgene* Polyethylene products are becoming the indispensable assistants in modern laboratories throughout the country.

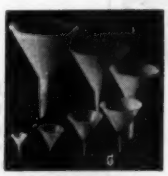
NALGENE* CENTRIFUGE TUBES made from POLYETHYLENE

These tubes are automatic machine molded from high molecular weight polyethylene. Being unbreakable and low in cost, they are a must in all laboratories.

Cat. No. 1210 Centrifuge Tubes, Nalgene* Polyethylene in 2 sizes
15 ML capacity, conical type at .50 each
50 ML capacity, round bottom type at .55 each
DISCOUNTS: Package lots of 36 of a kind less 10%; Lots of 144 assorted but not less than 36 of a kind less 15%

The 50ML size was especially designed with the high speed Servall centrifuge in mind. They are guaranteed to withstand these forces without leakage. They will also fit the International shield No. 320.

Whatever your needs in laboratory Polyethylene-ware, chances are there's a Nalgene unit for immediate service*



#1235E-FUNNELS

#1201E-1-BEAKER

#1212-WASH BOTTLES

#1208-CARBOYS

Write for our newest bulletin illustrating the many convenient Polyethylene laboratory assistants included in the Nalge line.

*Nalgene is the trademark for Nalge's Polyethylene-ware.

The NALGE CO., Inc.

ROCHESTER 2, NEW YORK, U.S.A.

EBERBACH LABORATORY SHAKERS

The utility box carrier on the variable speed power unit shown here is a most versatile laboratory shaker. Various size and shape containers (even a 5-gallon bottle as illustrated) are held securely by the rubber-covered sliding bar clamps. Speeds between 100 and 300 oscillations per minute. Interchangeable carriers for flasks are available. Durably built and attractively finished, Eberbach laboratory shakers are quality machines. Our Bulletin 100-H illustrates and describes the entire line of shakers in detail. Write for copy today.

Eberbach CORPORATION
SCIENTIFIC INSTRUMENTS & APPARATUS
ANN ARBOR, MICH. ESTABLISHED 1942

From our versatile line of high quality

PALO LABORATORY STIRRERS

with COMPLETE Speed Control

DIRECT DRIVE STIRRER

One of the most powerful laboratory stirrers available—a sturdy, direct drive stirrer offering the power and stamina necessary for the heavier stirring applications. Can be used for many semi-industrial jobs.

- 1/12 HP motor
- Table-top speed control rheostat
- 0 to 5000 RPM
- 5/16″ true running chuck
- Continuous duty
- Stainless Steel mounting rod
- Used with any laboratory support
- 110 volts, AC-DC

Model 7605E $45.65

Write for Descriptive Bulletin 5404R.

GEAR DRIVE STIRRER

The heaviest gear drive stirrer of the PALO line, incorporating all the features of power, ruggedness and durability—with the addition of reduction gears giving high torque at low speeds.

Model 7609C

$70.95

- 1/18 HP motor.
- Table-top speed control rheostat.
- High speed shaft to 5000 RPM.
- Low speed shaft to 833 RPM with a maximum torque of 3.0 in. lbs.
- 5/16″ true running chuck.
- Stainless steel mounting rod.
- Can be used with any laboratory support.
- 110 volts, AC-DC.

Write for descriptive Bulletin 6128-R.

See Your Regular Supply Dealer or Write Directly to Us

PALO
Formerly Palo-Myers, Inc.

LABORATORY SUPPLIES, Inc.
81 Reade Street, New York 7, N. Y.

● Available from the Engineering Societies Library, 29 W. 39th St., New York 18, New York, is ESL Bibliography No. 9, "Bibliography on filing, classifications, and indexing systems for engineering offices and libraries," 79 annotated references, 18 pages (mimeographed), for $2.

This is a selected list of references prepared for engineers and librarians concerned with organizing their own files or the files in the engineering offices or libraries where they work. The references are to articles in magazines, books, and pamphlets on filing, classification and indexing, lists of subject headings, and hand-sorted punched-card systems suitable for organizing small collections of engineering books, notes, correspondence, abstracts, reprints, drawings, maps, catalogues, etc. Some of the listed items are general; some are related to specific subject fields. There is a four-page introduction in which selection and use of the systems are discussed.

● A new edition of "Facts about oil," a reference booklet containing up-to-date statistics and other data on the petroleum industry, has recently been published by the American Petroleum Institute. Single copies may be obtained by writing to the American Petroleum Institute, 50 W. 50th St., New York 20, New York. Bulk copies are available at $20 per hundred. Copies of the booklet also are being made available to libraries and other informational sources. Illustrated with photographs and line drawings, the booklet provides information on the oil industry in these broad sections: origin, exploration, drilling, production, transportation, refining, supply and demand, marketing, uses, and general economics.

● Bulletin 100, a new 4-page, 2-color catalogue covering precision bore tubing is available from Wilmad Glass Co. Landisville, New Jersey. Listed in tabular form are the various sizes of precision bore and precision bore capillary tubing carried in stock. Of major significance are the tolerance limits to which this precision bore tubing is processed . . . plus or minus 0.0002 inch on the i.d. or the o.d. In certain sizes the wall thickness can be made between 0.015 and 0.3125 in. Besides the precision bore round tubing, a variety of shapes and sizes are available.

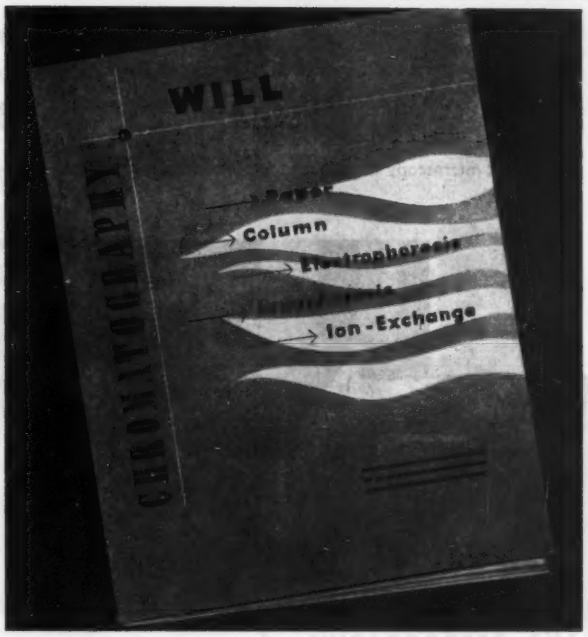
● Corning Glass Works has announced the publication of a new bulletin covering Pyrex brand E-C Coated Tubes for Laboratory Heating Jackets.

E-C Coated Tubing provides a tubular heat source that permits observation of processes within the tube. It is useful in laboratory processes such as atmospheric and reduced pressure general service distillation and fractioning petroleum products.

The eight-page bulletin includes wiring diagrams, operating data, general performance characteristics, and instructions for temperature control. This information will be of interest to anyone concerned with process heating.

Copies of the bulletin may be obtained free of charge by writing Corning Glass Works, Corning, New York.

● The Barnstead Still & Stearilizer Co. has just published a new bulletin No. 128 which according to the manufacturer



Get this new

CHROMATOGRAPHY CATALOG

Use this guide for looking up every type of equipment for experimental chromatography.

In 36 pages, it fully illustrates, describes, and prices equipment, apparatus, and supplies for chromatography, including solvents and adsorbents.

You'll find it most handy for fulfilling your requirements this fall.

COMPLETE . . . AUTHORITATIVE . . . FULLY REFERENCED

Leading makes of equipment are presented in various price ranges, especially chosen to facilitate selections within your budget.

Included are many of the new items never before listed.

And to save you time, this new catalog is fully and authoritatively documented with references.

Send for your copy now. There's no cost or obligation. Just use the coupon below, or call your nearest WILL office-warehouse today.

Clip and mail this coupon today

WILL Corporation, P.O. Box 1050, Rochester 3, N. Y.

Gentlemen: Please send me the new WILL Chromatography Catalog.

Name_____ Department_____

Organization_____

Address_____

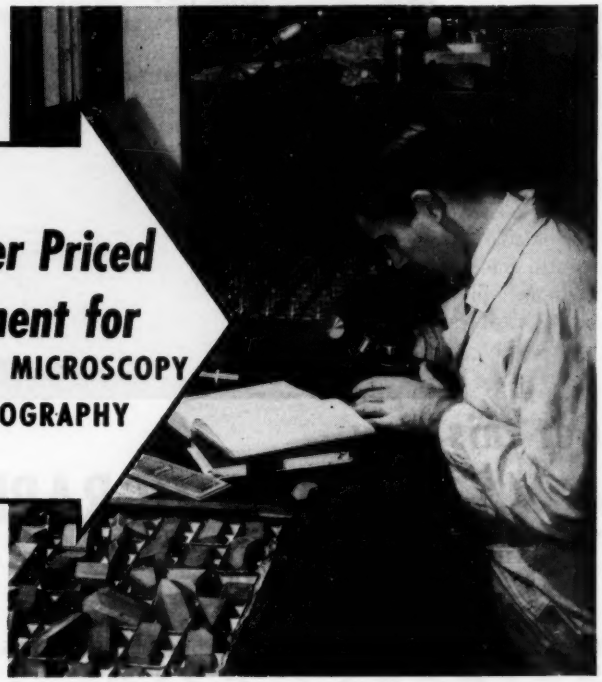
City_____ Zone_____ State_____

Will CORPORATION
and subsidiaries

Specialists in (WILL) *Scientific Supply*

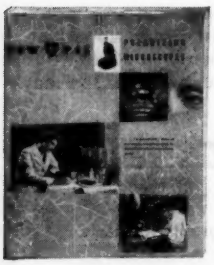
ROCHESTER 3, N. Y. • ATLANTA 1, GA. • NEW YORK 12, N. Y. • BALTIMORE 3, MD. • BUFFALO 5, N. Y.

Educational and industrial laboratories have *enthusiastically* received the new AO P45 Microscope. This precision polarizing microscope is priced to encourage wider application of the rapid methods of polarized light microscopy to problems of chemistry, petrology, and crystallography.



A Lower Priced Instrument for CHEMICAL MICROSCOPY AND PETROGRAPHY

The instrument is simple, convenient in operation, sturdily constructed to withstand inexperienced hands and has a built-in light source. It retains highest quality AO Spencer optical and mechanical features throughout.



Descriptive Catalog.
Attractively illustrated.
For your copy
write Dept. 1-67

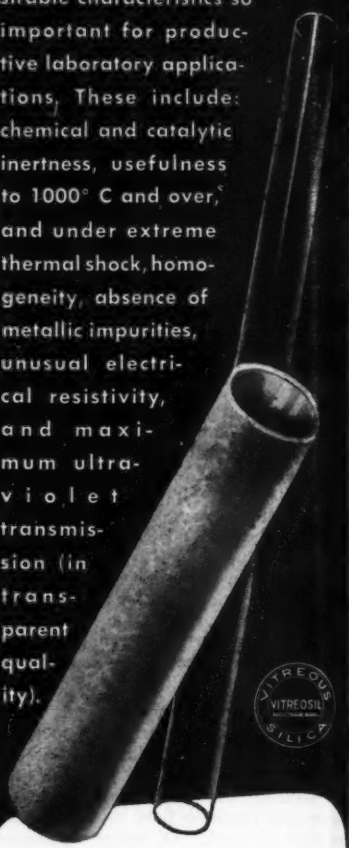
The built-in polarizer and removable body tube analyzer have precision optical quality Polaroid elements. Standard AO strain-free objectives, eyepieces and compensators are accommodated. Suitable for powers up to 430X, numerical apertures up to 0.66.

See the AO Spencer P45 Polarizing Microscope at your first opportunity.

American Optical
INSTRUMENT DIVISION • BUFFALO 15, NEW YORK

FOR YOUR MOST EXACTING REQUIREMENTS

VITREOSIL (vitreous silica) tubing has numerous desirable characteristics so important for productive laboratory applications. These include: chemical and catalytic inertness, usefulness to 1000° C and over, and under extreme thermal shock, homogeneity, absence of metallic impurities, unusual electrical resistivity, and maximum ultraviolet transmission (in transparent quality).



VITREOSIL is available from stock in four dependable types:

- **TRANSPARENT**
- **GLAZED**
- **SAND SURFACE**
- **SATIN SURFACE**

Stock sizes (transparent) up to 32mm. bore; opaque to 4½" bore available immediately. Larger diameters supplied on special order.

OBTAINABLE IN ALL STANDARD LENGTHS

Bulletin No. 18 with specifications and prices, sent upon request.

THE THERMAL SYNDICATE LTD.
14 BIXLEY HEATH
LYNBROOK, N. Y.

describes in detail the New Barnstead Pressure Bantam Water Demineralizer. It delivers demineralized water under pressure so that it can be piped to any desired point where the mineral-free water is actually used.

The demineralizer employs a renewable cartridge containing ion-exchange resins easily replaceable when exclusive Barnstead Pura-Lite (purity indicating light) goes out when new cartridge is needed.

The bulletin gives a complete description of the ion-exchange process and how ionizable impurities are removed. A copy of Barnstead Pressure Bantam Bulletin No. 128 may be had by writing to Barnstead Still & Sterilizer Co., 108 Lanesville Terrace, Forest Hills, Boston 31, Massachusetts.

• Scientists who require specially designed laboratory apparatus may now select custom-made items from a new catalog published by Corning Glass Works. More than 2600 pieces of special apparatus, many of which have never before been listed formally, are included in catalog CA-1, "Custom-Made Glassware By Corning." Detailed description of each piece includes an illustration, code number, size, and price. Normally all items will be fabricated to tabulated specification, but should slight variations be desired, they may be indicated easily.

The new catalog will be sent free of charge to persons writing on company letterhead to Special Apparatus Section, Laboratory and Pharmaceutical Sales Department, Corning Glass Works, Corning, New York.

• Details of a new Paper Electrophoresis System including all instrumentation for a standardized operating procedure is described in a new folder, Form 4R-554, available from Specialized Instruments Corp., 670 O'Neill Ave., Belmont, California. The equipment is illustrated both in an operating group and in closeup to show special features. A detailed description and list of specifications are included to cover the Durrum-type vertical electrophoresis cell; the Duostate automatically-regulated, constant-current/constant-voltage power supply; and the Spinco Analytrol recorder-integrater which automatically measures and records relative concentration of separated components.

• A 16-page catalog, Number 53A, covering the company's line of glass products has been announced by Friedrich and Dimmock, Inc., Millville, New Jersey. Included are complete application data tables which cover dimensions, weights, wall thicknesses and prices for glass tubing and rod, capillary tubes, low-pressure gage glass tubes, oil-cup glass cylinders, and glass wool fiber used in filtration processes. Working tolerances are given for almost all products as well as dimensions of all glassware carried in stock. Ordering information for each product is complete. Additional information as well as copies of the catalog are available from Friedrich and Dimmock, Inc., Millville, New Jersey.

from policemen to carboys . . .
if it's made of *Polyethylene*—

MACHLETT

can fill your needs

S74-997 KEMFLEX TUBING

Inside Diam.	Wall Thickness	Less than 50 Feet*	50 to 99 Feet*	100 to 999 Feet*	Over 1000 Feet*
1/8"	1/16"	$.30	$.21	$.17	$.12
3/16"	1/16"	.40	.28	.22	.16
1/4"	1/16"	.48	.32	.25	.19
3/8"	1/16"	.52	.38	.32	.26
1/2"	1/16"	.65	.46	.40	.33

*Above prices are per foot.

S5-778 BOTTLES WITH POLYETHYLENE SCREW CAPS

Large sizes—16 oz., and ½, 1 and 2 gallon size—supplied with polyethylene Buttress Caps

CAPACITY (oz.)	1	2	4	8	16
NECK FINISH (mm.)	20	20	24	28	38
EACH	$ .25	.35	.40	.45	.65
DOZEN	$1.80	1.90	3.00	3.65	5.75

CAPACITY (oz.)	32	½ gal.	1 gal.	2 gal.
NECK FINISH (mm.)	38	38	38	38
EACH	1.20	3.95	5.00	9.65
DOZEN	11.00	40.00	50.00	100.00

S36-851 FUNNELS

Outside Diameter (in.)

Top	Top of Stem	Bot. of Stem	Stem Lgth.	Each	Doz.
3	7/16	5/16	3"	$1.00	$10.00
4	11/16	5/8	1 5/8"	1.25	12.50
6	13/16	5/8	3 1/4"	1.40	14.00
7¼	1	7/8	3 1/8"	1.50	15.00

S5-294 BEAKERS

Capacity ml.	30	70	100	150	200
Each List	.65	.70	.75	.80	.90
Capacity ml.	300	400	600	800	
Each List	.95	1.00	1.45	1.65	

S77-832 POLICEMEN

One end flattened with diagonally cut edge. Size 7" long, ¼" diam.—$.40 Each.....$3.60 per Dozen

S77-831 STIRRING RODS

Same as Policeman but without flattened and diagonally cut end. Size 6¼" long, ¼" diam.

$.35 Each.....$3.00 per Dozen.

S12-471 LIGHTWEIGHT CARBOYS

(with polyethylene Buttress Caps)

Capacity Gallons	Each	Lots of 6, Each	Lots of 12, Each
6½	$20.00	$19.00	$18.00
13	32.00	30.00	28.00

S12-472 JACKETED CARBOYS

Capacity Gallons	Lots of 1–2, Each	Lots of 3–5, Each	Lots of 6–12, Each
6½	$30.00	$27.00	$24.50
13	42.00	37.50	35.00

S49-991 JARS

With airtight cover and metal carrying handles. Height 10", Top Diameter 8⅝", Bottom Diameter 7".

$3.00 Each.....$32.50 per Dozen.

S49-991/1 JARS

Same as above, but without cover and carrying handles.

$2.00 Each.....$20.00 per Dozen.

28-441 CYLINDERS, GRADUATED

Capacity (ml.)	Subdivisions	Each	Lots of 6, Each	Lots of 12, Each
500	25 ml.	$11.50	$10.00	$ 9.00
1000	50 ml.	13.75	12.00	10.00

S7-128 WASH BOTTLES

Capacity (oz.)	Each	Lots of 3, Each	Lots of 12, Each
4	$ .90	$ .80	$ .63
6	1.00	.90	.70
8	1.10	1.00	.75
16	1.40	1.30	1.20
32	2.00	1.80	1.60

S6-301 DROPPING BOTTLES

2 oz. cap...$.50 Each...$5.00 per Dozen

S5-779 POUR OUT SPOUTS

For bottles with 38 mm. neck finish only

$.75.....$7.50 per Dozen

ALL PRICES F.O.B. NEW YORK, N. Y.

Four page folder for your files available on request.

MACHLETT Laboratory — E. MACHLETT & SON — 220 East 23rd Street • New York 10, N.Y. — APPARATUS · SUPPLIES · CHEMICALS

Before You Order

YOUR LAB CHEMICAL REQUIREMENTS THIS MONTH...

Ask B&A *to Bid*

Where "So Much Depends on So Little"

In the educational laboratories and research centers of our colleges and universities, where the work habits of future scientists are being molded, it is vital that only the most reliable... the highest quality reagent chemicals be used!

For such work, remember B&A Quality Reagents and "C.P." Acids always comply with the exacting standards established by the American Chemical Society for reagents suitable for careful, analytical work.

That's why so many conscientious department heads and purchasing agents in educational institutions from coast to coast always specify Baker & Adamson Reagents . . . the *reliable, premium quality* brand which has set the pace in chemical purity since 1882.

REAGENTS B&A STANDARD OF PURITY FINE CHEMICALS

GC Allied Chemical

BAKER & ADAMSON® *Reagent Chemicals and C.P. Acids*

GENERAL CHEMICAL DIVISION

ALLIED CHEMICAL & DYE CORPORATION

40 RECTOR STREET, NEW YORK 6, N. Y.

Offices: Albany* • Atlanta • Baltimore* • Birmingham* • Boston* • Bridgeport* • Buffalo* Charlotte* • Chicago* • Cleveland* • Denver* • Detroit* • Houston* • Jacksonville • Kalamazoo Los Angeles* • Minneapolis • New York* • Philadelphia* • Pittsburgh* • Providence* • St. Louis* San Francisco* • Seattle • Kennewick* and Yakima (Wash.)

In Wisconsin: General Chemical Company, Inc., Milwaukee

In Canada: The Nichols Chemical Company, Limited • Montreal* • Toronto* • Vancouver*

SETTING THE PACE IN CHEMICAL PURITY SINCE 1882

*Complete stocks carried here

Ludwig Ebert

(See page 458)

The Improved Welch CATHETOMETER

- *Vertical range 100 cm*
- *Vernier reading to 0.05 mm*
- *Telescope with rack and pinion*
- *Working distance 45 cm to infinity*
- *Tangent screw adjustment*
- *Level sensitive to 50 seconds of arc*
- *Vertical shaft of Stainless Steel*

This latest improved design of the Welch cathetometer possesses a combination of features not hitherto available in an inexpensive instrument. It can be leveled and placed in proper adjustment easily and rapidly, yet all adjustments have sufficient sensitivity and delicacy of control to please the most meticulous user.

Rack-and-Pinion Focusing

The telescope is held securely in two V-shaped supports and is equipped with a sensitive tubular level and a fine-motion tangent screw with which its optical axis can be adjusted to the horizontal. Focusing is by rack and pinion. For working distances under 100 cm an auxiliary lens, which fits over the objective lens, is provided. The objective is an achromat with an aperture of 20 mm. A Ramsden eyepiece and 90° spider cross hairs are employed.

Sensitive Elevation Adjustment

The telescope carriage is individually fitted with great care on the vertical support rod. It is held at the desired elevation by two collars but is free from them and is capable of 360° rotation about the vertical rod. Wide bearing surfaces of the carriage insure smooth rotation about the vertical rod without change of elevation. The upper collar carries the vernier scale and is coupled by means of a fine-pitched elevation adjustment screw to a supplementary collar below, the latter being clamped in position to allow for the final setting of the telescope with the fine adjustment. The vernier scale remains on the main scale regardless of the direction of the axis of the telescope.

Vertical Rod of Stainless Steel

The support rod is rust-proof stainless steel 30 mm in diameter and selected for straightness. The graduations are engine divided for uniformity and accuracy and the numerals are large and clear. It is divided in millimeters.

The tripod base is cast iron with a radius of 21 cm to give ample stability. It is equipped with leveling screws and footplates. A small circular level is mounted in the base for rapid preliminary leveling.

A full-length plastic cover and a set of instructions are included. No. 68A **Each, $196.50**

No. 68A.

Write for Literature

Manufacturers of Scientific Instruments and Laboratory Apparatus

W. M. WELCH SCIENTIFIC COMPANY

DIVISION OF W. M. WELCH MANUFACTURING COMPANY

ESTABLISHED 1880

1515 SEDGWICK STREET, DEPT. D CHICAGO 10, ILLINOIS, U.S.A.

Editor's Outlook

THIS is being written while the First Chemistry Institute, at the University of Wyoming, is still in session. This Institute, we may hope, will be the first of others to come, for it is pretty sure to go down as a significant success. This is not the first, to be sure, of gatherings of chemistry teachers who meet to discuss their mutual problems; indeed, at least one such "workshop" has been held during each of the last several summers, sponsored by the Division of Chemical Education of the American Chemical Society. But the First Chemistry Institute is no ordinary "workshop," as the advance notices of it carried in THIS JOURNAL have shown. It is not different only in its duration and the method of choosing its participants but in a more important way. Its program has been organized entirely upon the theme: Recent Advances in Chemistry. Experts with world-wide reputations in many specialized fields of chemistry review these fields and bring them up to date for the members of the Institute.

The emphasis is thus put where, to my mind, it justly belongs—upon the content of the material we teach. If there is any *one* thing we can do to promote teaching efficiency it is to insure that the teacher knows as much as possible about his subject. It takes a very clever teacher to teach something he doesn't know himself! To a certain extent, of course, the teacher can be expected to keep himself abreast of recent advances by his own reading, but this is a poor substitute for the inspiration of hearing about solar and atomic energy from Daniels, about natural tritium from Libby, and about the origin of the elements from Gamow.

All this must have strongly influenced the National Science Foundation in its decision to support the Institute so generously. Without this substantial backing it would not have been possible. Let us hope that the final results will encourage repetition—or competition from some other source.

THOSE of us who have put it together think that the present issue is a rather unusually good one. I don't often do this, but I would like to point out two or three particular features. The lead-off article on the abundance of the elements, by Fleischer, is one of the most generally interesting and readable reviews we have had. Incidentally, we have several more of these in various stages, on different subjects, which we hope will approach this standard.

The article on the applicability of the equilibrium law, by DeFord, has many implications and should be of great use to teachers who try to keep their students from going off into dangerous jungles. It should bring down to earth the mathematical gyrations which so frequently go on in analytical chemistry.

The last item is the letter by Julius Sumner Miller (page 496). My purpose in mentioning it is to point out that THIS JOURNAL is itself a source of the material he describes. Our advertisers are ready and anxious to supply our readers with samples and other industrial material of many kinds. You don't need to look further; try it.

THE ABUNDANCE AND DISTRIBUTION OF THE CHEMICAL ELEMENTS IN THE EARTH'S CRUST[1]

MICHAEL FLEISCHER
U. S. Geological Survey, Washington, D. C.

THE study of the abundance and distribution of elements in the earth's crust is so broad that no more than a sketchy survey can be made here. Every chemist should have some familiarity with the subject, but the general experience of those whose work deals with raw materials has been that many chemists are not acquainted with the sources of the elements and compounds that they use. A story, probably apocryphal, is told of the college senior who, when asked to name the sources of potassium compounds, replied, "There are three sources—Merck, Baker, and Mallinckrodt."

Staff of U. S. Geological Survey Laboratory of Physical and Chemical Research, 1888

Left to right, rear: F. W. Clarke, W. F. Hillebrand, T. M. Chatard, J. Hallock; front, J. E. Whitfield, F. A. Gooch, Carl Barus, and R. B. Riggs. Whitfield was later a partner for many years in the laboratory of Booth, Garrett, and Blair, Philadelphia; Gooch was Professor of Chemistry at Yale College; Barus was Professor of Physics at Brown University; Riggs was Professor of Chemistry at Trinity College, Hartford, Connecticut.

In this paper an attempt is made to look a little deeper than that into the subject: to summarize the data on the abundances of the elements, to discuss their distribution among different types of rocks, and to examine the causes of the observed variations in distribution.

As might be expected, the abundance and distribution of the elements were long ago subjects of interest. More than 100 years ago estimates of abundance were made by Döbereiner in Germany, and a list of the types of rocks in which 59 elements were most likely to be found was made by de Beaumont, a French geologist. Other estimates of the abundances of the elements appeared in later years but were not accurate because few reliable analyses were available.

The first estimates of the abundance of elements of any accuracy were made about 1890 after the methods of quantitative analyses of rocks had been greatly improved. This improvement was due largely to the work of the chemists of the U. S. Geological Survey. From 1880 to 1910 this group put the determination of the major constituents of rocks on a firm basis and also showed that more consideration should be given to some of the less abundant elements, such as titanium, vanadium, and molybdenum.

The leader in this analytical work was W. F. Hillebrand, chemist of the U. S. Geological Survey from 1880 to 1909 and chief chemist of the National Bureau of Standards from 1909 to 1925.[2] More than any other person, Hillebrand was responsible for the methods of inorganic analysis that we are using today. His book, "The Analysis of Silicate and Carbonate Rocks," first appeared in 1897 as a brief section in U. S. Geological Survey Bulletin No. 148. It was so popular that revised editions appeared in 1900, 1907, and 1910; widened in scope, it reappeared in 1929 as "Inorganic Chemical Analysis," by Hillebrand and Lundell, which has been called "the bible of inorganic analysis"; a revised edition appeared in 1953.

With sound methods of analysis, it became possible to make meaningful estimates of the abundance of the elements. F. W. Clarke, chief chemist of the U. S. Geological Survey, gathered the data and published them in his famous monograph, "The Data of Geochemistry," of which five editions were published in 1908, 1911, 1916, 1920, and 1924. The fifth edition, published as

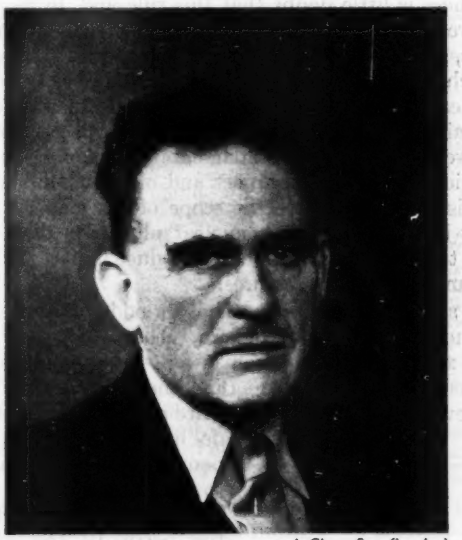
[1] Publication authorized by the Director, U. S. Geological Survey

Modified from a talk given to five New England sections of the American Chemical Society, March, 1950.

[2] For biographies and appraisals of Hillebrand, see WATERS, C. E., *Proc. Am. Chem. Soc.*, **1925**, 53–60; CLARKE, F. W., *Nat. Acad. Sci. Biographical Mem.*, **12**, 43–70 (1928); ALLEN, E. T., J. CHEM. EDUC., **9**, 73–83 (1932).

U. S. Geological Survey Bulletin No. 770, is now out of date but is still in so much demand that it has been reprinted twice in the last few years.[3] A revision, which will require several years, is now under way.

During this same period, others contributed much to our knowledge, among them H. S. Washington in the United States, J. H. L. Vogt in Norway, and V. I. Vernadsky in Russia. In the 1920's a laboratory of geochemistry arose at the University of Oslo, Norway, under the leadership of V. M. Goldschmidt. In a series of nine papers, he and his co-workers Zachariasen, Barth, Lunde, and others used the new tool of X-ray crystallography to deduce the principles of crystal chemistry and further applied these principles to the elucidation of the occurrences of the elements. From 1929 to 1935, when he was expelled by the Nazis, Goldschmidt was at the University of Göttingen, where he used the spectrographic method of analysis for the less abundant elements and greatly extended our knowledge in this direction. He continued his work at Oslo and, after escaping from Norway, in England until his death in 1947.[4] Similar work was done in Germany and Scandinavia, especially by the Noddacks and by Hevesy. Research in this field is active in Scandinavia, England, Germany, and the United States; much of it can be traced to Goldschmidt's influence.



J. Chem. Soc. (London)

V. M. Goldschmidt, 1888–1947

Another great center of research in geochemistry has been Russia. Work there was led by V. I. Vernadsky, whose first papers on distribution of the elements appeared in the 1890's, and by his student A. E. Fersman. Vernadsky particularly emphasized the effects of biological processes on the dispersion and concentration of the elements. Some aspects of this field, which he named biogeochemistry, are discussed below. Fersman was a prodigious worker; he published nearly 700 papers, including a dozen large monographs. He emphasized the application of thermodynamics and of quantitative measurements of energy changes to the study of geological processes.[5]

W. F. Hillebrand, 1853–1927

It is pleasant to be able to close this brief historical

[3] For biographies of Clarke, see MUNROE, C. E., *J. Am. Chem. Soc.*, **57**, 21–30 (1935); DENNIS, L. M., *Nat. Acad. Sci. Biographical Mem.*, **15**, 139–65 (1932).

[4] See BERNAL, J. D., "Goldschmidt memorial lecture," *J. Chem. Soc. (London)*, **1949**, 2108–14; TILLEY, C. E., *Obituary Notices of Fellows of the Royal Society*, **6**, 51–66 (1948).

[5] See SPENCER, L. J., *Am. Mineralogist*, **31**, 173–8 (1946) on Fersman; STADNICHENKO, T. M., *ibid.*, **32**, 181–8 (1947) on Vernadsky.

F. W. Clarke, 1847–1931

TABLE 1
The Twelve Most Abundant Elements in the Earth's Crust[a] (Including the Oceans and Atmosphere)

	% *by wt.*
Oxygen	49.5
Silicon	25.7
Aluminum	7.5
Iron	4.7
Calcium	3.4
Sodium	2.6
Potassium	2.4
Magnesium	1.9
Hydrogen	0.9
Titanium	0.6
Chlorine	0.2
Phosphorus	0.1
	99.5

[a] From ANDERSON, J. S., *J. Proc. Roy. Soc. N. S. Wales*, **76**, 329–45 (1943). For other estimates, see FLEISCHER, M., "Recent estimates of the abundances of the elements in the earth's crust," U. S. Geol. Survey Circular No. 285 (1953).

review by noting that in the last few years important research in this field has been resumed in the United States. The first comprehensive book on geochemistry[6] to be published in English since the fifth edition of Clarke and also the first textbook of geochemistry in English[7] have appeared during the past few years. Powerful stimuli have been the discovery of the importance of traces of various elements to plants and animals and the interest of nuclear physicists in cosmic phenomena.

ABUNDANCE OF ELEMENTS IN THE EARTH'S CRUST

The percentages by weight of the 12 most abundant elements in the upper ten miles of the earth's crust are given in Table 1. It will be noted that one element, oxygen, constitutes nearly half the earth's crust and that the 12 most abundant elements constitute 99.5 per cent; all the other 86 elements combined constitute only 0.5 per cent of the earth's crust. Nine elements—those of atomic numbers 43, 61, 85, 87, 93, 95, 96, 97, and 98—have not yet been shown to occur naturally at all.

The abundance in the earth's crust of all the elements is given in Figures 1 and 2. Several points deserve attention. First, as pointed out by W. D. Harkins over 30 years ago, it is apparent that most of the earth's crust is composed of elements of low atomic number. Second, the elements of even atomic number are far more abundant than those of odd atomic number. Third, as a general rule—called the Harkins-Oddo or even-odd rule—an element of odd atomic number is less abundant than the two adjacent elements of even atomic number. Exceptions to this rule are evident in Figures 1 and 2, and some of these will be discussed later, but the rule does hold for most of the elements.

There is little doubt that this rule and, in fact, the entire pattern of the abundance of the elements reflect laws, not yet fully understood, that govern the way in which neutrons, mesons, protons, and electrons are and can be assembled to form the elements. Whoever explains the why of Figures 1 and 2 will be close to answering this most fundamental problem. Further consideration of this subject and of the abundance of the isotopes is outside the scope of this paper, but it may be mentioned that nuclear physicists have been able to set up equations that reproduce in part the facts summarized in these figures.[8]

A striking exception to the even-odd rule is that the abundances given for helium, neon, argon, krypton, and xenon are very much lower—by a factor of ten thousand to one million—than one might expect from the even-odd rule. As these are gaseous elements that do not readily form compounds, it seems plausible to assume that these were lost from the molten crust of the earth to the atmosphere, and from there partly lost into space. This explanation is supported by

[6] RANKAMA, K., AND TH. G. SAHAMA, "Geochemistry," University of Chicago Press, Chicago, 1950.

[7] MASON, B., "Principles of Geochemistry," John Wiley & Sons, Inc., New York, 1952.

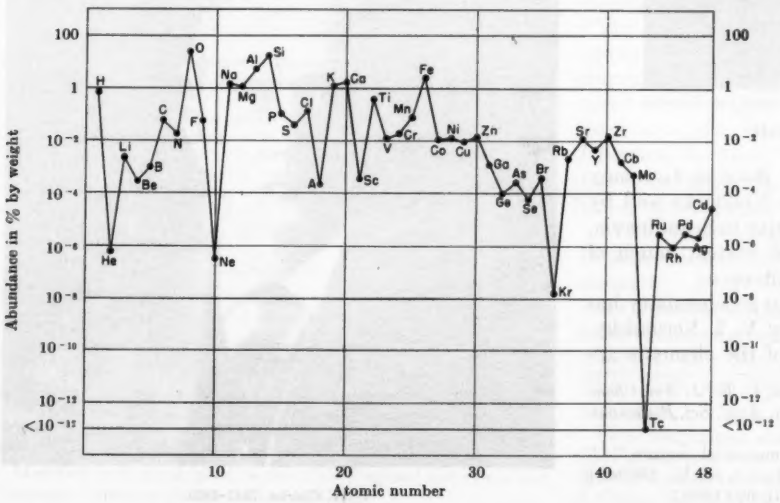


Figure 1. Abundance in the Earth's Crust of Elements of Atomic Numbers 1 to 48

[8] See, *e. g.*, TER HAAR, D., "Can we account for the observed abundances of the chemical elements?" *Am. J. Phys.*, **17**, 282–7 (1949); SINGWI, K. S., AND B. K. AGARWALA, "The abundance distribution of elements," *Proc. Nat. Inst. Sci. India*, **17**, 425–36 (1951); ALPHER, R. A., AND R. C. HERMAN, "Theory of the origin and relative abundance distribution of the elements," *Rev. Modern Physics*, **22**, 153–212 (1950).

spectrographic study of the stars, which indicates that the rare gases are far more abundant there than in the earth's crust. Some of the other exceptions to the even-odd rule that appear in Figures 1 and 2 are due to the fact that the data are for the composition of the top ten miles of the earth's crust, not for the composition of the earth as a whole. It is generally believed[9] that the core of the earth is composed of nickel-iron metal, and that below the ten-mile crust there is an extensive zone of rocks low in silicon and rich in magnesium, iron, and chromium. This would explain the anomalously low abundances shown in Figures 1 and 2 for magnesium and chromium, and perhaps also those for sulfur, selenium, and tellurium.

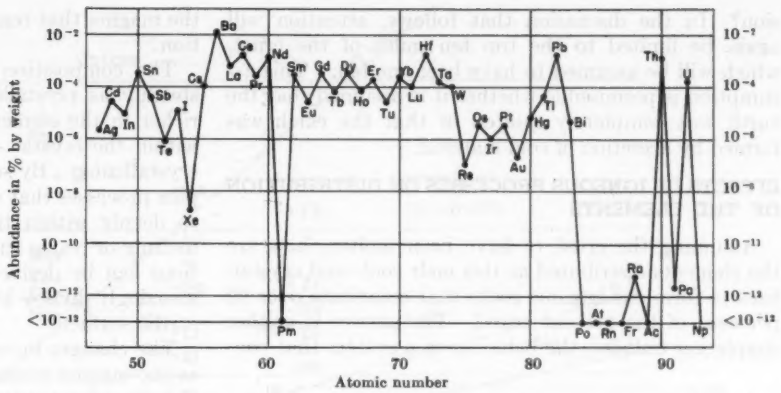


Figure 2. Abundance in the Earth's Crust of Elements of Atomic Numbers 47 to 93

TABLE 2

Ratio of Concentration in Commercially Minable Ores to Average Content in Earth's Crust[a]

Metal	*A, % workable*[b]	*B, abundance, %*	*Concentration factor, A/B*
Iron	30.0	4.7	6
Copper	1.0	0.007	140
Nickel	1.5	0.008	190
Manganese	25.0	0.10	250
Tin	1.0	0.004	250
Zinc	8.0	0.013	620
Chromium	25.0	0.02	1250
Gold	0.001	5×10^{-7}	2000
Platinum	0.001	5×10^{-7}	2000
Lead	5.0	0.0016	3100
Silver	0.05	1×10^{-5}	5000

[a] Modified from Schneiderhöhn, 1932.
[b] This varies greatly with such factors as size of deposit, accessibility, and presence of other elements.

A glance at the same figures shows some startling discrepancies for several elements between their abundances and our familiarity with them. Note, for example, in Figure 1, how much more abundant vanadium and zirconium are than the more familiar silver and cadmium, and that the "rare" element scandium is more abundant than the "common" arsenic. Similarly, as seen in Figure 2, the little-known—to most of us—elements hafnium, cerium, lanthanum, and neodymium are much more abundant than such familiar elements as tin, antimony, iodine, platinum, gold, and mercury.

This disparity between abundances and familiarity is discussed below, but first it is desirable to translate the figures given for abundance into more commonplace terms. The average abundance of uranium in the earth's crust may be taken as 0.0002 per cent[10] or two parts per million. Calculation shows that a city lot 50 by 100 feet, completely excavated to a depth of one mile, would yield approximately five tons of uranium, if the element could be extracted completely. The uranium content might be twice the average if the lot were in an area of granitic rocks. It would probably be much less than average if the lot were on basaltic rocks or on limestone. Assuming that one had a lot with the average content of uranium, the five tons now have a market value of about $35,000, not to mention such possible by-products as the gold present, whose value is nearly $3000.

Before any reader begins to purchase mining equipment, it should be pointed out that it would be necessary to mine two and one-half million tons of rock to extract the five tons of uranium, and to refine it to a 20 per cent concentrate.

DISTRIBUTION OF THE ELEMENTS IN THE EARTH'S CRUST

The consideration of average abundance of the elements leads us to the problem of their distribution, concentration, and dispersion among the various types of rocks in the earth's crust. Obviously, ores are not usually mined unless the element desired is present in greater concentration than its average content in the crust. Table 2 gives some estimates of the ratio of concentration necessary before an element occurs in minable form. The ratio varies greatly for different elements. Because it depends not only on such constant properties of the element as its chemical behavior and the physical properties of its minerals but also on the inconstant value man attaches to the elements, the ratio varies with social factors. Ten years ago an ore of uranium had to contain nearly two per cent to be worth mining—a concentration ratio of 10,000—but that is not the lower limit today.

What are the processes by whose operations the elements, perhaps once distributed uniformly, arrived at their present variations in concentration and disper-

[9] See RANKAMA AND SAHAMA, *op. cit.*, pp. 74–83.

[10] Recent estimates range from 0.00002 to 0.0009 per cent.

sion? In the discussion that follows, attention will again be limited to the top ten miles of the crust, which will be assumed to have been molten. This assumption is permissible whether it is assumed that the earth was completely molten or that the earth was formed by accretion of cold material.[11]

EFFECTS OF IGNEOUS PROCESSES ON DISTRIBUTION OF THE ELEMENTS

Assuming the crust to have been molten, how are the elements distributed as this melt cools and crystallizes to form the igneous rocks that constitute over 90 per cent of the present crust? The answer is neither simple nor unique; the behavior of a system that contains at least 10 to 20 components and that will not always reach equilibrium is not to be described in a few minutes. However, from geological studies and from laboratory studies of silicate systems at the Geophysical Laboratory of the Carnegie Institution of Washington, the following simplified picture can be drawn.[12]

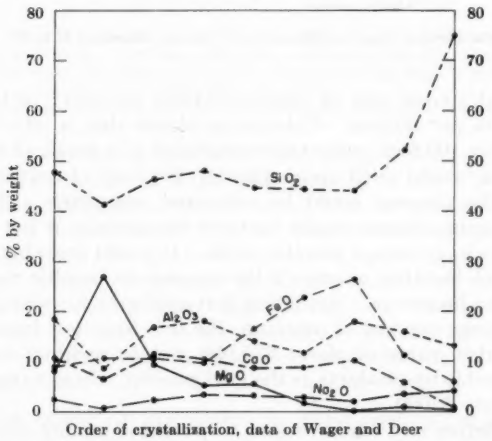


Figure 3. Changes in Concentration of Major Elements as Crystallization Proceeded, Skaergaard Intrusive

The first compounds to crystallize from the melt are magnesium-iron-aluminum-chromium oxides (the spinels), magnesium-iron(II) silicates (the olivines and orthorhombic pyroxenes), followed by and in part with calcium-magnesium-iron silicates (the monoclinic pyroxenes) and calcium-rich calcium-sodium-aluminum silicates (the plagioclase feldspars). If these early-formed compounds sink in the remaining molten magma or crystallize at the bottom, they form the "basic" rocks, low in silicon, high in magnesium. Commonly the separation is incomplete and the rock that results has large crystals of early-formed minerals (phenocrysts), with a finer grained groundmass that represents the magma that remained molten just before solidification.

The composition of that residual magma changes steadily as crystallization proceeds; it is continually richer in the elements that cannot be accommodated within the crystal structures of the minerals that are crystallizing. By such a process and by the more complex processes that occur if a crystallized rock is buried so deeply within the crust that it undergoes partial melting or reacts with molten material, magmatic solutions can be derived that are capable of forming the amazingly diverse kinds of igneous rocks that are found at the surface.

The changes in concentration of the major elements as one magma crystallized are shown in Figure 3. The Skaergaard intrusive in East Greenland is one of the most thoroughly studied rock masses of the world and is therefore used as an example, even though its composition is somewhat abnormal, especially in its high iron content and low potassium content. The figures at the left, obtained by analysis of the chilled margin of the mass, are believed to represent the composition of the original magma. Going to the right, the points represent the composition of rocks formed successively as crystallization proceeded. Note how rapidly magnesium was depleted in the residual magma and how the silica content rose slowly up to the last fraction to crystallize, which was only about half a per cent of the total magma; the silica content of this last fraction was very high.

As might be expected, there is some variation in behavior when the original magma has a composition differing from that shown in Figure 3, but geological evidence indicates that the general pattern of behavior of the major elements is similar to that shown in Figure 3.

The obvious question is, Knowing the behavior of the major elements present in the cooling magma, can one predict the behavior of the minor elements? This may be rephrased: If it is known what compounds of

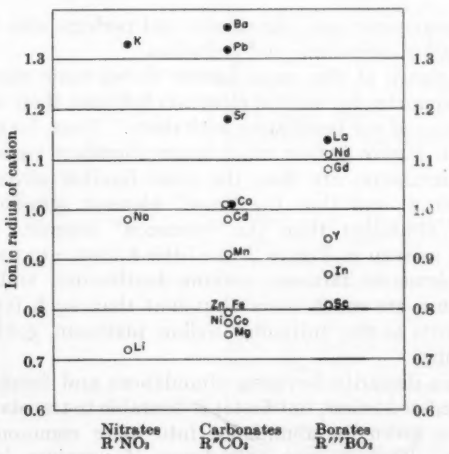


Figure 4. Effect of Cationic Radius in Determining Crystal Structure

○ = Rhombohedral. ● = Orthorhombic

[11] UREY, H. C., "The Planets, Their Origin and Development," Yale University Press, New Haven, Conn., 1952; *Geochim. et Cosmochim. Acta*, 1, 209–77 (1951); *ibid.*, 2, 263–8 (1952).

[12] An excellent presentation is given by OSBORN, E. F., "Segregation of elements during the crystallization of a magma," *J. Am. Ceram. Soc.*, 33, 219–24 (1950).

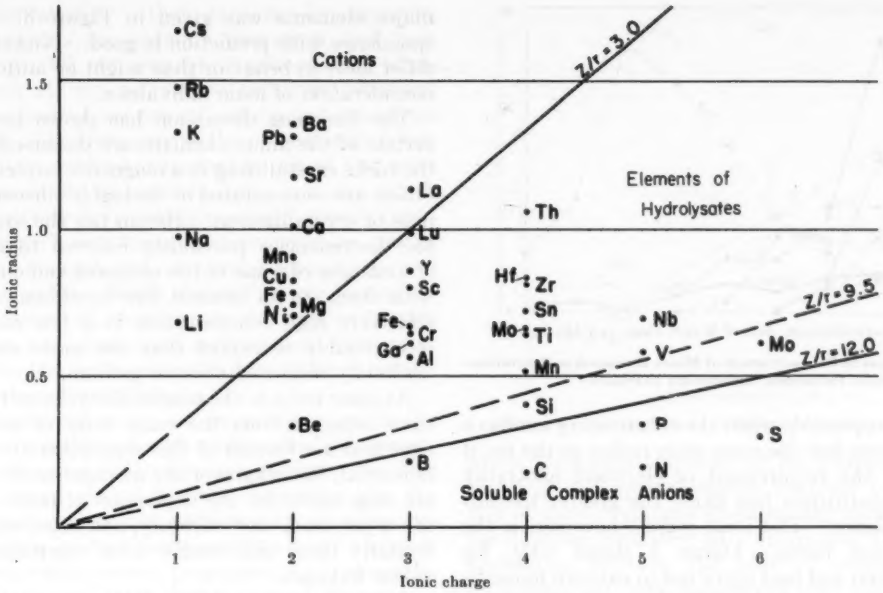


Figure 5. Grouping of Certain Elements According to Their Ionic Radii and Charges

Diagonals are lines of constant value for the ionic potential, Z/r (ionic charge divided by ionic radius). Modified after Goldschmidt (1937).

the major elements are crystallizing from solutions containing other elements as well, can one tell which minor elements are likely to be associated with which major elements?

The answers come from the young science of crystal chemistry that began with von Laue's discovery in 1912 of the diffraction of X-rays by crystals and the application of this new knowledge to the study of crystals by the Braggs. In 1923 Wasastjerna in Finland determined the ionic radii of the fluoride and oxide ions, and in the following six years Goldschmidt and his coworkers applied the results of crystal chemistry to the study of isomorphous replacements as they occur in nature.

In the discussion that follows, the effects of covalent bonding are ignored, as nearly all the compounds mentioned except the sulfides are largely ionic in nature. Likewise the effects due to polarizability of ions are ignored.[13] Perhaps the most important discovery of crystal chemistry is that ionic radius, not valence, is the major controlling factor that determines which elements can substitute for others in crystals. It was shown that substitution of an element for another of different valence is possible, provided that the ionic radii are nearly the same and provided that electrical neutrality of the crystal is maintained either by a concomitant substitution or by leaving a position unfilled in the crystal. For example, in the plagioclase feldspar series sodium can replace calcium (note the ionic radii in Figure 5), and electrical neutrality is kept by the simultaneous substitution of silicon for aluminum, so that the solid solution series ranges in composition from $Ca(Al_2Si_2)O_8$ to $Na(AlSi_3)O_8$.

One of the simplest examples of the effect of ionic radius on crystal structure is illustrated in Figure 4, which shows that for a group of compounds of formula XYO_3, in all of which the YO_3 groups are about the same size, the radius of the cation is the factor that determines which of two crystal structures the compound has. Calcium carbonate is dimorphous, but the orthorhombic form is metastable. The crystal structures of gadolinium and neodymium borates have not yet been determined. From their positions in Figure 4 it seems possible that they too will be dimorphous.

The ionic radii of some of the elements are plotted in Figure 5; the values given are for sixfold coordination. The general rule formulated by Goldschmidt is that elements can usually substitute for one another in crystals if their ionic radii are within 15 per cent of one another. This is a rough approximation only, as many other factors are important. For example, substitution is easier at high temperatures than at low, and easier in loosely packed structures than in close-packed structures.

Substitution is easiest when the substituting ion has both the same ionic radius and the same valence as the ion it replaces. A glance at Figure 5 shows why nickel is nearly always present in magnesium minerals, and why gallium is so closely associated with aluminum.

[13] Detailed discussion is given in STILLWELL, C. L., "Crystal Chemistry," McGraw-Hill Book Co., Inc., New York, 1938; EVANS, R. C., "An Introduction to Crystal Chemistry," Cambridge University Press, Cambridge, England, 1939; WELLS, A. F., "Structural Inorganic Chemistry," Oxford University Press, Oxford, England, 1950.

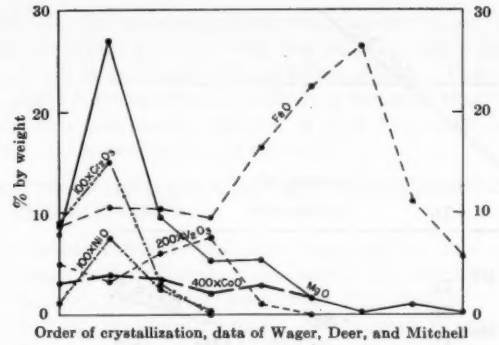


Figure 6. Changes in Concentration of Minor Elements as Crystallization Proceeded, Skaergaard Intrusive

Substitution is possible when the substituting ion has a different valence but the same ionic radius as the ion it replaces, but the requirement of electrical neutrality makes the substitution less likely the greater the difference in valence. The ionic radius, however, is the most important factor. Figure 5 shows why, for example, barium and lead occur not in calcium minerals but in potassium minerals, and why niobium is commonly found in titanium minerals.

It will be recalled (Figure 3) that magnesium, iron, calcium, and aluminum are the major cations of the compounds that crystallize early, and it will be noted that all of these have ionic radii of intermediate size (Figure 5). One can then predict what elements are most likely to concentrate in the last liquid fractions of the magma. They will include elements of large ionic radii such as potassium and barium, elements of very small ionic radii such as beryllium and boron, and elements of intermediate ionic radii such as zirconium, thorium, and niobium, which have much higher valences than the major compound-forming elements.

Figure 6 shows data for some of the minor elements of the same rock mass for which the behavior of the major elements was given in Figure 3. The correspondence with prediction is good. Nickel and cobalt differ more in behavior than might be anticipated from consideration of ionic radii alone.

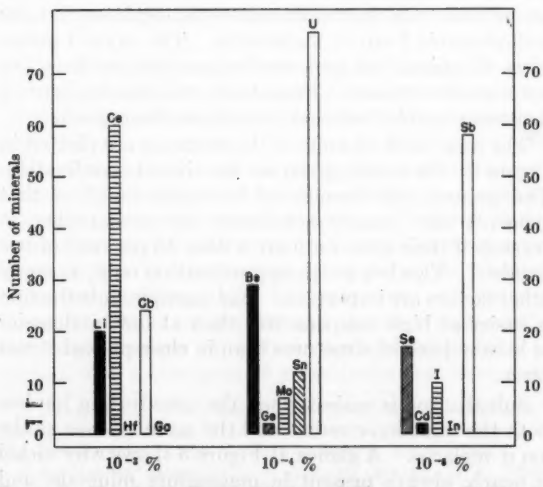


Figure 7. Abundance Versus Number of Minerals in Which the Element Is a Major Constituent

The foregoing discussion has shown how and why certain of the minor elements are dispersed throughout the rocks crystallizing in a magmatic sequence, whereas others are concentrated in the highly siliceous end products of crystallization. Herein lies the explanation of the discrepancies previously referred to between the abundances of some of the elements and our familiarity with them, as an element like beryllium, occurring in relatively high concentration in a few rock types, is more readily recovered than the more abundant but uniformly dispersed element gallium.

At some point in the magmatic cycle, sulfur-rich solutions separate from the main body of magma. The time and mechanism of this separation are highly controversial, but whatever the mechanism these solutions are responsible for the deposition of most ore deposits of copper, lead, zinc, mercury, and other elements, particularly those that readily form compounds with covalent linkages.

A rough measure of the relative concentration or dispersion of some of the elements is given in Figure 7, in which is plotted the number of minerals in which the element is a major constituent. Gallium accompanies aluminum, hafnium accompanies zirconium, and indium accompanies zinc so closely that they are not major constituents in any minerals. These are the elements called "dispersed" by Vernadsky. Germanium and cadmium are also dispersed elements; cadmium accompanies zinc, and germanium accompanies silicon in rocks and zinc in sulfide ores. Of the other elements shown in Figure 7, lithium, cerium, niobium, beryllium, and uranium, along with some tin, are concentrated in residual magmatic solutions, as discussed above. Selenium, antimony, and some tin are concentrated in sulfides. The unusually large number of uranium minerals is due partly to the concentration of uranium in residual magmatic solutions, and partly to its easy oxidation to sexivalent uranium which permits the formation during weathering of a large number of secondary uranium minerals.

EFFECTS OF WEATHERING PROCESSES ON DISTRIBUTION OF THE ELEMENTS

We shall now consider briefly what happens when the igneous rocks we have been discussing are decomposed by the chemical attack of the atmosphere and ground waters. Water and carbon dioxide are the principal reagents. Rock minerals may be altered to other minerals or may be dissolved completely, perhaps to precipitate elsewhere, perhaps to be carried to the ocean. Sedimentary deposits may be residual deposits (material that did not dissolve), mechanical detritus, chemical precipitates, or evaporites (formed by evaporation of ocean water), or combinations of these.

The sedimentary rocks, although they constitute only five per cent of the earth's crust, are extremely im-

portant economically;[14] they include, for example, most of our ores of tin, titanium, zirconium, and thorium (residual), all our ores of aluminum and phosphorus, much of our manganese and iron (chemical precipitates), and all our ores of sodium and potassium (evaporites). The chemistry of the processes by which the sedimentary rocks are formed is one of the most intriguing problems of geochemistry, and one which received relatively little attention until recent years. It is now known[15] that uranium is concentrated during the chemical precipitation of marine phosphates and marine black muds. Black shales that are formed by the consolidation of these muds commonly contain more copper, vanadium, and molybdenum than most igneous rocks, but not even the form in which these elements are present is now known.

Few generalizations can yet be made to guide the study of the formation of such rocks and of the concentration and dispersal of the elements in them. In 1928 Cartledge showed that a function called by him the ionic potential, which was obtained by dividing the charge, Z, of the ion by the ionic radius, r, gave empirical correlations with certain properties of the elements. Goldschmidt showed later that a plot of Z versus r, such as in Figure 5, could be divided into sectors and that elements with similar values of Z/r showed similarity in their behavior during the weathering cycle. For example, he predicted the elements that would be concentrated during the process that converted a rock containing about 20 per cent Al_2O_3 into bauxite containing about 50 per cent Al_2O_3. His statement follows:[16]

> Besides beryllium and gallium, which follow aluminum, the elements titanium, zirconium, tin, and quinquevalent niobium are found to be concentrated in bauxite, together with aluminum hydroxide, and the factor of concentration is about the same as that of alumina, being as a rule about 4–5-fold as compared with their mother rock.* In some cases vanadium also is somewhat concentrated in the bauxites. The tervalent elements with somewhat lower ionic potential, such as the lanthanides, yttrium, and even scandium, are as a rule not concentrated in typical bauxites, because their lower ionic potential permits their removal in aqueous solution.

The prediction in the footnote of the quotation above came true when the Aluminum Company of America announced in 1949 the commercial production of gallium from residues of bauxite treatment. Curiously enough, although Goldschmidt's predictions have been verified qualitatively, no quantitative test appears to have been published until very recently. Part of the results of a quantitative study[17] is shown in Figure 8,

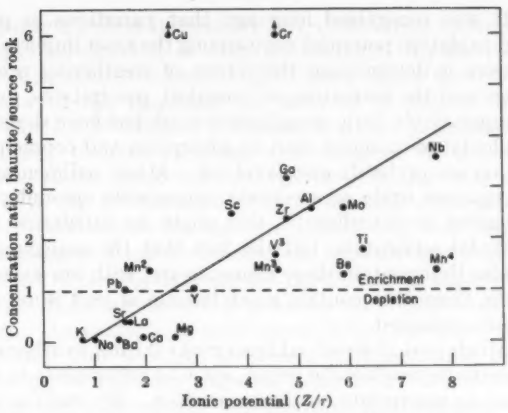


Figure 8. Concentration of Elements in Arkansas Bauxites

which illustrates the ratio of concentration found by chemical and spectrographic analyses of 15 bauxites and of three nepheline syenites, the rocks from which the bauxites were derived. In general, there is a good correlation between the ratio of concentration and ionic potential, with unexpected high concentrations of copper and chromium, and less concentrations of beryllium than expected.

This is only a small part of the story, however, and many other factors are known to be important. For example, the igneous rock peridotite, composed chiefly of olivine $(Mg, Fe)_2SiO_4$, is known to weather to two very different end products. In one type, the product of weathering is lateritic iron ore, composed principally of hydrous iron oxides. Silicon and magnesium have been nearly quantitatively removed, but the original chromium and nickel contents remain essentially unchanged.[18] The chromium presumably remains as the unattacked residual mineral chromite, but the form in which nickel is present is not certainly known. Few data are available on other minor elements and their fate in this type of weathering. In the second type, however, weathering of the same kind of rock has resulted in the formation of hydrated nickel-magnesium silicates with Ni:Mg ratios up to 100 times as great as in the original rock. Much of the silicon and magnesium and practically all of the iron have been dissolved, though some silicon and iron were reprecipitated not far away as quartz and hydrated iron oxides. Likewise, the small amount of manganese originally present reappears as a hydrated manganese dioxide that seems to have acted as a scavenger, because it is found to contain appreciable amounts of cobalt, copper, lithium, and barium, but very little nickel.[19] The chemical separations that nature has here made are not at all what one might expect from the separations in systematic qualitative analysis!

[14] McKelvey, V. E., et al., "Value of domestic production of minerals from various classes of rock," *Econ. Geol.*, **45**, 470–9 (1950).

[15] McKelvey, V. E., and J. M. Nelson, "Characteristics of marine uranium-bearing sedimentary rocks," *ibid.*, pp. 35–53.

[16] Goldschmidt, V. M., *J. Chem. Soc.* (*London*), **1937**, 667.

* I may mention that the alkali aluminate solutions of the Baeyer process for making alumina are a potential source for very large quantities of gallium.

[17] Gordon, M., Jr., and K. J. Murata, "Minor elements in Arkansas bauxite," *Econ. Geol.*, **47**, 169–79 (1952).

[18] See, *e. g.*, Frasche, D., "Origin of the Surigao iron ores," *ibid.*, **36**, 280–305 (1941).

[19] Pecora, W. T., "Nickel silicate and associated nickel-cobalt-manganese-oxide deposits near São José do Tocantins, Goiaz, Brazil," U. S. Geol. Survey Bulletin No. 935-E, 247–305 (1944).

It was recognized long ago that variations in pH and oxidation potential were among the most important factors in determining the course of weathering processes and the formation of chemical precipitates, but comparatively little quantitative work has been done.[20] Colloidal phenomena such as adsorption and coprecipitation are probably also involved. Many sedimentary manganese oxide ores contain appreciable amounts of tungsten or vanadium;[21] this might be attributed to colloidal adsorption, but the fact that the manganese oxides that contain these elements are, with few exceptions, those that contain much barium or lead is not so easily explained.

Much that is dissolved from rocks during weathering eventually reaches the ocean, some to accumulate in it, some to precipitate on the ocean floor. By making an estimate of the amount of the earth's crust of average

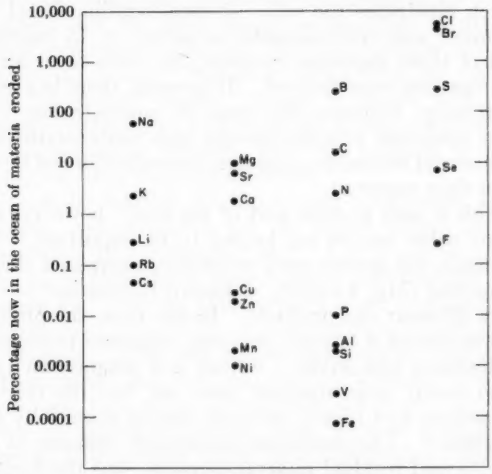


Figure 9. Proportion of Elements Eroded from Lands That Have Remained Dissolved in the Ocean

composition that has been eroded and comparing it with the present content of the ocean, one obtains the data plotted in Figure 9. It is noteworthy that these calculations indicate that the ocean contains nearly all the sodium, but only about four per cent of the potassium that has reached it. The reason that the ocean is not a KCl solution as well as an NaCl solution seems to be that the larger potassium ions fit better into the structures of the micas, hydrous micas, and glauconite, and precipitate in the form of these minerals, which are important constituents of marine shales.

The calculations indicate that the oceans contain more chlorine, bromine, boron, and sulfur than could have been supplied by erosion. A reasonable explanation is that large amounts of these elements are supplied by volcanic activity.

Still another factor in the formation of sedimentary deposits is the intervention of living matter. Bacterial activity is known to have a very important influence on sulfate-sulfur-sulfide equilibria under certain conditions, and it has been postulated, but remains uncertain, that bacteria have played a decisive role in the formation of petroleum and coal. Despite uncertainty as to their origin, there is good evidence of the existence in nature of organic complexes such as metal-porphyrin compounds.[22] Such complexes may be the explanation of the notable concentrations of vanadium and nickel in certain petroleums—concentrations so high that vanadium has been profitably recovered from the flue dust of oil-burning ships. Similarly, coal has been shown to contain high concentrations of many elements, notably germanium and gallium.[23]

Living plants also can concentrate certain elements. In recent years, soils scientists, botanists, and agricultural chemists have demonstrated the existence of many plant and animal diseases caused by deficiencies in various elements, among which cobalt, boron, and manganese may be mentioned. They have also shown that certain plant and animal diseases are caused by the toxic effects of excessive amounts of certain elements such as selenium and molybdenum.

Selenium in soils and plants has been studied very thoroughly[24] by the U. S. Department of Agriculture and by state laboratories, especially in South Dakota and Wyoming. Certain plants accumulate selenium—concentrations up to 15,000 parts per million of selenium have been reported—and the plants may contain several hundred times as much selenium as the soils on which they grow. The seleniferous soils of our western states are derived largely from certain shales, but it is not yet known in just what form the selenium is present in these shales.

PRACTICAL APPLICATIONS

Mineral raw materials are now being consumed at an unprecedented rate, and it is clear that new sources must be found for many elements. Three major fields of research toward this goal are the improvement of methods of beneficiation and smelting of ores so that lower grades can be used, the development of methods for the recovery of minor elements from the by-products

[20] See, however, KRUMBEIN, W. C., AND R. M. GARRELS, "Origin and classification of chemical sediments in terms of pH and oxidation-reduction potentials," *J. Geol.*, **60**, 1–33 (1952); HUBER, N. K., AND R. M. GARRELS, "Relation of pH and oxidation potential to sedimentary iron mineral formation," *Econ. Geol.*, **48**, 337–57 (1953).

[21] FLEISCHER, M., S. K. NEUSCHEL, AND J. M. AXELROD, "Tungsten and vanadium in manganese oxides," in preparation.

[22] HABERLANDT, H., "Concentration of rare elements in mineral formations due to additions of organic origin," *Forschungen u. Fortschr.*, **20**, 154–5 (1944); BLUMER, M., "Porphyrinfarbstoffe und Porphyrin-Metallkomplexe in schweizerischen Bitumina," *Helv. Chim. Acta*, **33**, 1627–37 (1950); SKINNER, D. A., "Chemical state of vanadium in Santa Maria crude oil," *Ind. Eng. Chem.*, **44**, 1159–65 (1952).

[23] STADNICHENKO, T., K. J. MURATA, P. ZUBOVIC, AND E. L. HUFSCHMIDT, "Concentration of germanium in the ash of American coals," U. S. Geol. Survey Circular No. 272, 1–34 (1953); MORGAN, G., AND G. R. DAVIES, "Germanium and gallium in coal ash and flue dust," *Chemistry & Industry*, **56**, 717–21 (1937).

[24] See TRELEASE, S. F., AND O. A. BEATH, "Selenium," **1949**,

of ore smelters, and the search for new geophysical and geochemical methods of finding ore deposits. All three fields are under study.

During the past decade much work has been done on geochemical prospecting by the analysis of soils, plants, or waters in the hope that abnormally high concentrations of metallic elements may be found that can be traced back to ore deposits.[25] Such prospecting requires that analyses be made on hundreds of samples, and it has been necessary to devise rapid, fairly accurate methods that can be used in the field with a minimum of equipment. It is to be anticipated that geochemical prospecting will be very widely used, now that the necessary analytical methods are available.[26]

The improvement of smelting methods and the recovery of minor elements are primarily metallurgical problems, but the geochemist has the important job of providing information as to just what minor elements might be expected in what associations. In the past less attention was paid in the United States than elsewhere to the possibility of recovery of smelter by-products. In the past few years, however, germanium, gallium, indium, rhenium, and thallium have been added to the list of elements recovered in this country.

With the development of spectrographic and colorimetric techniques for the determination of very small percentages of many elements, the tools are now available for obtaining data on the occurrence of these elements and their distribution among the constituents of ores. An example of such research is a recent report showing that niobium is present in appreciable percentage in titanium minerals associated with alkalic rocks and with certain residues from the treatment of Arkansas bauxite.[27] It is to be hoped that there will be a great expansion of research along these lines.

[25] Abstracts of 151 papers are given by HARBAUGH, J. W., U. S. Geol. Survey Bulletin No. 1000-A, 1–50 (1953).

[26] LAKIN, H. W., H. ALMOND, AND F. N. WARD, "Compilation of field methods used in geochemical prospecting by the U. S. Geological Survey," U. S. Geol. Survey Circular No. 161 (1952).

[27] FLEISCHER, M., K. J. MURATA, J. D. FLETCHER, AND P. F. NARTEN, "Geochemical association of niobium and titanium and its geological and economic significance," U. S. Geol. Survey Circular No. 225, 1–13 (1952).

LE CHATELIER'S PRINCIPLE AND THE EQUILIBRIUM CONSTANT

ARILD J. MILLER
Carleton College, Northfield, Minnesota

MANY students of chemistry have difficulty in understanding how the position of equilibrium in a gaseous reaction can change when the pressure is altered, in accordance with Le Chatelier's principle, without causing a corresponding variation in the equilibrium constant. This problem is common, not only among students in general chemistry and qualitative analysis, but also among advanced students who have perhaps never studied the problem in a quantitative way. Practically all students can predict correctly the effect of changing the pressure on the position of equilibrium, once the statement of the principle has been learned or memorized; but when asked for an explanation of why the shift occurs, it usually proves impossible for them to develop a satisfactory theory.

The following scheme has proved very useful to the author in helping students with this difficulty, and does not appear in the common texts and reference books.

Consider the system represented by the equation

$$N_2 + 3H_2 \rightleftarrows 2NH_3 \qquad (1)$$

to be at equilibrium. The equilibrium constant for this reaction is expressed in the usual form,

$$K_p = \frac{(p_{NH_3})^2}{(p_{N_2})(p_{H_2})^3} \qquad (2)$$

Suppose now that we double the total pressure by compressing the volume to one-half its original volume. This momentarily doubles the pressure of each constituent of the reaction mixture. Thus, before the system can readjust to the new situation, we have:

$$"K" = \frac{(2p_{NH_3})^2}{(2p_{N_2})(2p_{H_2})^3} = K_p/4 \qquad (3)$$

Since the equilibrium constant is a constant at constant temperature (except for deviations from ideality which occur at high pressures and which need not be considered here), the equilibrium must shift in such a way that "K" will be increased until it is equal to K_p. This occurs, of course, by the reaction of nitrogen with hydrogen to form more ammonia, which increases the value of the numerator and decreases the value of the denominator of (3), until "K" becomes equal to K_p, when the system is again at equilibrium.

This suggestion does not prove that the equilibrium will shift until "K" = K_p, but it does show that there can be a shift in the position of equilibrium without a change in the value of the equilibrium constant. It has been the author's experience that the use of this method of explanation clarifies the concept of equilibrium to many students who had difficulty in this area.

WHAT THE EDITORS OF THE JOURNAL OF THE AMERICAN CHEMICAL SOCIETY EXPECT OF AUTHORS[1]

MARSHALL GATES
University of Rochester, Rochester, New York

THE function of the *Journal of the American Chemical Society* as viewed by the Board of Directors of the Society is to publish all the reliable new fundamental chemical information it receives, whether from members of the Society or from nonmembers, here or abroad. In practice two easily distinguishable features of this function can be discerned. The *Journal* must serve as a forum in which new ideas, new theories, new results, and new speculations can be propounded, discussed, argued over, and either substantiated or refuted. Through this function it stimulates further research and speculation, and in order to insure the free flow of new ideas and speculations it must guard against the tendency of scientific orthodoxy to suppress unconventional opinions. In short, the *Journal* must adequately reflect the contemporary state of chemical knowledge and point the direction in which new research is proceeding. The second and very different function performed by the *Journal* is the establishment of a permanent repository or archive for the recording of chemical facts. These two functions differ markedly in character, and the policy reached by the editors of the *Journal* is necessarily a compromise between the two. Both are important, but their importance varies with time in a completely different way. The first of them is of considerably greater current importance in that it reflects contemporary chemical thinking and stimulates new thought and experimentation, but its value tends to decrease with time. The second, which may be considered of less current importance, acquires a permanent value which may decrease with time but at a very much slower rate. An example will make this clear. The chemist of today very often consults the *Berichte* of 1880 but almost never for the theoretical content of the papers recorded therein. He is ordinarily interested in experimental facts and physical constants recorded. Thus the *Berichte* of this period has largely an archival value. Its value for the stimulation of new ideas and theories is very much lower than it was in von Baeyer's time.

The problems of the editors of scientific journals differ greatly from those of ordinary editors in that manuscripts are neither solicited nor paid for, little or no advertising, with its attendant problems, is handled, and appeal to readers is not the principal concern of the editors. Some might argue that appeal to readers should be more their concern than it now is, but from the standpoint of the two functions just described one must conclude that appeal to readers in the usual sense is of secondary importance.

With this preliminary account of the function of the *Journal* and the problems of the editors a start can be made toward describing what the editors expect of authors. Foremost among the requirements of the *Journal of the American Chemical Society* and presumably of other comparable journals is novelty. To be acceptable for publication the work must be new and not previously published by the same or other authors. The experimental work, the results, the conclusions or the ideas must one or more be novel. Significant new ideas based on already published experimental work or new conclusions so based all fall within the definition of novelty used by the editorial staff of the *Journal*, as do new experimental results which lead to or confirm older ideas or conclusions. The editors, however, expect authors to distinguish between really new material and material which although pertinent to the paper is not novel in this sense, and to introduce only enough material of the latter description to make a clear exposition of the former possible. To fill the paper with an exhaustive literature review in which the current state of knowledge of a field is discussed ordinarily violates this requirement. Only enough introductory material to place the new results in the background of existing knowledge in the field should be given, and I am glad to say that largely through the efforts of Professor Arthur B. Lamb over a long period of years most of the chemists in this country now writing for the *Journal of the American Chemical Society* have come to accept this qualification. Experimental results must be novel in some significant way over those published earlier. If the measurements or descriptions are new, well and good, but, if they are repetitions of earlier measurements or descriptions, they must represent significant and demonstrable improvement over earlier descriptions to qualify as novel in the sense demanded by the *Journal*. Minor variations in technique are, of course, not sufficient to justify publication of repetitious material.

In addition to novelty the results should possess some significance, *i. e.*, they should be other than trivially significant as well as novel. Significance is a very difficult

[1] Presented as part of the Symposium on What Editors Expect of Authors and Why, at the 123rd Meeting of the American Chemical Society, Los Angeles, March, 1953.

concept to assess and one that cannot even be defined accurately. Undoubtedly the editors of the *Journal* make many errors in attempting to assess the significance of various articles. However, it is the policy of the editors of this *Journal* and presumably of other scientific journals to err on the side of liberality in attempting to assess this aspect of a paper. Thus a compilation of physical properties, provided that they are new and reliably determined, would be considered significant enough to publish, even though originality and resourcefulness may be otherwise almost entirely lacking in the manuscript.

It is quite obviously beyond the ability of a few individuals to judge manuscripts from a wide variety of fields as to novelty and significance, and therefore the editors of the *Journal of the American Chemical Society* and also the editors of most scientific journals make use of a board of editors selected for their knowledge and critical ability to aid in the assessment of the suitability of manuscripts for publication. In addition to the board of editors, however, a great many external referees are relied on, and almost all manuscripts are examined by at least one external referee, who is also chosen for his knowledge and critical ability in a given field.

In addition to novelty and significance, to be acceptable to the *Journal of the American Chemical Society* the material must be presented concisely. Several reasons for this exist. This *Journal*, in common with almost every other scientific and technical journal, has had for the past few years increasingly heavy demands for its space and has at the same time faced rapidly rising production costs. It is clear that it is the editor's responsibility toward the society he represents and toward his subscribers to use the space allowed him in the most economical and efficient way, and this, of course, demands conciseness in the preparation of articles. An equally important reason for conciseness is, however, the fact that if important material is buried in a welter of verbiage and irrelevant material its significance is very much more difficult to recognize. There are many examples of a scientific work being delayed in general acceptance by disorganized and overly long presentation. An author owes it to himself, if not to his colleagues, to present his material as clearly and as concisely as possible. Unfortunately this is a point of view that is very difficult to impress on authors who, once having set pen to paper, somehow feel that the particular description they have written is immortal and should not be altered so much as one iota. A constantly recurring criticism of the *Journal* is that its insistence on brevity is such as to make the papers unintelligible and to force the deletion of essential portions of manuscripts. Perhaps I have acquired an unhealthy point of view in this respect in three years with the *Journal of the American Chemical Society*, but it is my firm conviction that in a high percentage of the cases in which we have asked an author to condense his material, an improved manuscript has resulted from this condensation. We have in fact often received letters from authors in which this improvement is acknowledged. Apropos at this point is the classic comment of one of our referees to the effect that the manuscript he had reviewed for us should either be reduced considerably or oxidized completely.

Editors have a right to expect from authors copy that is prepared according to the form customarily used by that journal, that is legible in all copies submitted, and that is prepared according to generally accepted standards of English usage. Typesetters must work from legible copy, and it is the responsibility of the author and not the editors to supply such copy. On the whole, authors recognize and accept this responsibility, and it is rare that we return a manuscript to an author because of its poor preparation, although this has been done. Not all methods of manifolding are suitable for the preparation of printers' copy. Mimeograph is notoriously bad for this purpose. Multilith is better, although the color is a disadvantage. However, several manifolding processes do give copy which is quite as acceptable as original typescript, and we are happy to receive well done manifolding.

The position of an editor would be very much simpler if all contributors were adept in the organization of subject matter and in its exposition in the English language. Unfortunately this is not the case. Our manuscripts vary greatly in quality from this point of view. Unfortunately the editors of scientific journals are ordinarily themselves not professional writers but scientists. The result of this is that the articles appearing in the *Journal of the American Chemical Society* and in many other scientific journals vary greatly in the skill with which the material is prepared. We are told by Dr. R. S. Cahn, editor of the *Journal of the Chemical Society*, that he and his assistants do a great deal of rewriting in order to assure a certain standard of exposition and a certain conformity to good usage in this British journal. Our office is unable to undertake a similar task for our *Journal*, and we make little attempt to, although in the occasional manuscript that is very bad in this respect or in the case of manuscripts from scientists whose native tongue may not be English, we do have some facilities for rewriting. Unfortunately it is ordinarily not sufficient merely to tell the author of a poorly written manuscript that the manuscript is unsatisfactorily written and should be rendered more orderly, clear, concise, and grammatical, since the manuscript as first submitted probably represented a fair sample of the author's ability to carry out such a writing assignment. Occasionally the editorial staff will attempt to rewrite a given paragraph or two as an illustration of what can be done, or occasionally a referee will undertake the same task, but this is as far as efforts in this direction are ordinarily carried.

The foregoing requirements apply to the articles and notes received by the *Journal*. In addition, a further category, with special requirements of its own, exists. I refer to the Communications to the Editor. The purpose of this section is to provide rapid publication of preliminary announcements judged to be of special

timeliness and significance, and the editors of the *Journal* expect authors to use this section only when their results meet this requirement. There is a tendency to regard the establishment of priority as enough to render a manuscript timely. This view is not shared by the editors.

Manuscripts submitted for this section pose special problems to the editorial staff, who must make not only an objective decision as to the novelty of the material, but a more difficult subjective decision as to its special qualities. As can be imagined, the rejection rate is high for Communications.

In closing, it seems worth while to mention that editors have a right to expect whole-hearted cooperation from authors in the revision of manuscripts to meet constructive criticism. This cooperation is freely given by most authors, but quite reluctantly by some, fortunately few in number.

LUDWIG EBERT

NELLY KONOPIK
University of Vienna, Vienna, Austria
(Translated by Ralph E. Oesper)

(Johannes) Ludwig Ebert was born on June 19, 1894, at Würzburg, the old episcopal and university city in Franconia (Bavaria). Those who knew this city before the widespread destruction by bombing in 1945 remember it as a place filled with festive cheerfulness and love of music, where Walther von der Vogelweide passed the sunset of his life, where Riemenschneider created his immortal art works, and where Roentgen discovered X-rays. Consequently, it is not difficult to see why the young Ebert was attracted simultaneously toward music and science. Though he finally decided in favor of science, and one of his sons, Klaus (at present assistant to F. Paneth at the Max Planck Institut in Mainz) followed in his footsteps, his three other children have acquired an international reputation in chamber music circles as the Ebert Trio.

Ebert began his chemical training in 1912 at Würzburg under E. Büchner and also studied physics under W. Wien. His military service and World War I consumed almost seven years and it was not until his return from captivity in France that he was really able to resume his studies, in the spring of 1920. The head of the chemical Institut at Würzburg was O. Dimroth (1872–1940), an organic chemist with a rare appreciation for the then rapidly developing physical chemistry. This branch was represented at the University of Würzburg by H. v. Halban (1877–1947), who was the pioneer in the use of photoelectric cells for solving chemical problems. Ebert became his co-worker and completed his doctoral dissertation under his guidance. This study dealt with the optical absorption of dissolved salts (*1*) and especially the validity of Beer's law for strong electrolytes; it also included an investigation of the optical (fine colorimetric) determination of the dissociation of picric acid (*2*). Both of these problems were the outgrowth of Ebert's previous close examination—several years prior to the work of Debye and Hückel—of the little recognized "anomalies of strong electrolytes," concerning which, at the suggestion of J. Stark, he had compiled the first comprehensive report (*3*) in the light of the pioneering studies of N. Bjerrum, J. N. Brönsted, and G. N. Lewis.

Because of these publications Bjerrum invited Ebert to come as a visiting worker in his Copenhagen laboratory. He worked there for two years, the second as Fellow of the International Education Board (Rockefeller Foundation). Here he determined the normal potential of the quinhydrone electrode in absolute methanol (*4*) and measured the dissociation constants of dibasic fatty acids (*4*) in this solvent in order to test Bjerrum's theory of the electrostatic influence of ionic charges on the strength of acids in a nonaqueous solvent. In 1924 Ebert published an extensive discussion of the relation between dielectric polarization and molecular structure (*5*), in which, *inter alia*, appeared in the literature for the first time the concepts and terms molecular-, electronic-, atomic-, and orientation polarization.

A grant from the Rockefeller Foundation enabled Ebert to spend 1925–26 at the Cryogenic Laboratory of the University of Leiden to study the dielectric constants of liquefied gases at extremely low temperatures. There resulted his well known estimates of quantities of zwitterions in ampholyte solutions (*6*) and the dissociation constants of hydrochloric acid in water solution (*7*).

From 1926 to 1928 he was a member of the large staff

which Fritz Haber assembled around himself at the Kaiser Wilhelm Institut für physikalische Chemie at Berlin-Dahlem. Here, together with J. Lange, Ebert started the precise determinations of the freezing points of strong electrolytes (*8*), particularly of salts with cations of controllable different sizes (tetraalkyl ammonium salts), studies which Lange later continued independently also in nonaqueous solvents.

Ebert became Privatdozent at the University of Berlin in 1928. Only a few days later he was called as extraordinary professor to his native Würzburg, as successor to H. G. Grimm. In the 1929 Leipzig lectures (*9*) he discussed "Dipole moment and internal molecular motions," and for the first time dealt with the height of the energy barrier as a measure for the more or less free mobility about C-C bonds. In Würzburg, in collaboration with G. Kortüm, he undertook intensive studies of photoelectric measurements of optical activity (*10*), especially in the ultraviolet region. With E. Waldschmidt he constructed the first laboratory appliance for determining dielectric constants (*11*). Together with R. Büll he discovered the first example, dichloroethylene, of the stability of a *cis* form in a vapor equilibrium (*12*). At this period (1932) be wrote (*13*) an extensive contribution, "Conductance and transport numbers in solutions," for the Wien-Harms "Handbuch der Experimentalphysik." In addition, he honored his teacher by putting out a German translation of Bjerrum's textbook of inorganic chemistry (*14*).

In 1934 Ebert accepted a call to the Technische Hochschule at Karlsruhe. Here, with the collaboration of U. v. Weber, he studied the thermal stability of the optically active carbon atom (*15*). The simplest optically active hydrocarbon, methylethylpropylmethane, exhibits incipient thermal decomposition at 400°C. but not a trace of racemization. Ebert's name, combined with that of G. Ibing, occurs in the well known Küster-Thiel *Tabellen* with respect to an analytical method for liquid mixtures from freezing-point determinations (*16*).

Professor Ebert came to his present post at the University of Vienna in 1940. Here, assisted by a succession of collaborators, he investigated experimentally the theory of binary mixtures. In particular, the limits of application of the usual Margules solution of the Gibbs-Duhem differential equation (*17*) were explored, and also the significance of Henry's law (*18*). He suggested a new method of determining the electron affinity of dissolved materials (*19*), a method which has as yet hardly been employed. The systematology of the acid-base function, worked out with N. Konopik (*20*), produced, among other results, the fact that the Lewis acids, as members of the larger class of "acceptor acids," are smoothly included in a simple system; and it demonstrated clearly the relation between acid-base and redox function. Ebert developed a scheme for the complete systematology of isocomplexes (*21*) and discussed the relation between the position of the melting point in dependence on the molecular structure (*22*). He offered an interpretation of P. W. Bridgman's high-pressure findings as early as 1947, and recently he has pointed out the possibility of the existence of a crystal-melt critical point under certain conditions, and has set up a simple general limiting law for the vapor pressure in regions of greatly reduced pressures (*23*).

This survey of the most important scientific achievements of Ludwig Ebert would be one-sided, however, if no mention were made of his pedagogical and human qualities. Outstanding is his fascinating skill in lecturing and carrying out demonstrations; his clear discussions always reach the heart of the subject. He is unusually broad-minded and well read in many fields and his willingness to help when and where he can is quite notable.

He has served the institutions of higher learning where he has taught in many other academic capacities. In Karlsruhe he was dean of the chemical faculty for four years. He served as one of the editors of the *Berichte der deutschen chemischen Gesellschaft* for several years, and since 1946 he has been an active member of the editorial board of the *Monatsheft für Chemie*. He is a member of the Vienna Academy of Sciences. His students and friends observed his sixtieth birthday in June of this year with appropriate ceremonies and greetings.

LITERATURE CITED

(1) *Z. physik. Chem.*, **112**, 321 (1924).
(2) *Ibid.*, **112**, 359 (1924).
(3) *Jahrb. Radioakt. u Elektronik*, **18**, 134 (1921).
(4) *Ber.*, **58**, 175 (1925).
(5) *Z. physik. Chem.*, **113**, 1 (1924).
(6) *Ibid.*, **121**, 385 (1926).
(7) *Naturwiss.*, **13**, 393 (1925).
(8) *Z. physik. Chem.*, **139**, 584 (1928); *ibid.*, **149**, 389 (1930).
(9) DEBYE, P., Leipsiger Vorträge, 1929, "Dipolmoment und chemische Struktur," Verlag Hirzel, Leipzig, 1929, p. 44.
(10) *Z. physik. Chem.*, (B), **13**, 105 (1931).
(11) *Chem. Fabrik*, **7**, 180 (1934); *Angew. Chem.*, **47**, 305 (1934).
(12) *Z. physik. Chem.* (A), **152**, 451 (1931).
(13) "Handbuch der Experimentalphysik," Akad. Verlag Gesellschaft, Leipzig, **1932**, Vol. 12, pp. 1–380.
(14) "Kurzes Lehrbuch der anorganischen Chemie," Verlag Springer, Berlin, **1933**.
(15) VON WEBER, U., *Z. physik. Chem.* (A), **179**, 295 (1937).
(16) *Angew. Chem.*, **53**, 128 (1940).
(17) *Monatsh.*, **80**, 731 (1949); *ibid.*, **81**, 551, 562 (1950).
(18) *Ibid.*, **84**, 181 (1953).
(19) *Anz. Akad. Wiss. Wien, Math. naturw. Kl.*, **1946**, 105.
(20) *Österr. Chem. Ztg.*, **50**, 184 (1949).
(21) *Monatsh.*, **81**, 61 (1950).
(22) *Ibid.*, **77**, 398 (1947).
(23) *Österr. Chem. Ztg.*, **55**, 1 (1954).

THE RELIABILITY OF CALCULATIONS BASED UPON THE LAW OF CHEMICAL EQUILIBRIUM

DONALD D. DeFORD
Northwestern University, Evanston, Illinois

For many years the law of chemical equilibrium has served as the basis for much of the theoretical treatment of analytical problems. Calculations of pH, solubilities, redox potentials, titration curves, feasibility of titrations, and titration errors are included in nearly all courses in quantitative analysis. Considerable effort is spent also on equilibrium calculations in courses in general and physical chemistry and in qualitative analysis. With the possible exception of problems in stoichiometry, problems based upon the law of chemical equilibrium are undoubtedly accorded more attention than any other type of numerical problem. Papers dealing with the mathematics and the mechanics of setting up and solving equilibrium problems appear in the literature at frequent and regular intervals. Several such papers[1] have appeared in recent issues of THIS JOURNAL; similar papers, too numerous to list here, have appeared elsewhere.

On the other hand, the more fundamental question of the reliability of the results of equilibrium calculations has received very little attention either in the classroom or in the textbooks. The reason for this neglect is obvious; it is almost impossible to make generalizations which are applicable to all or even to most of the problems which may be encountered. Despite the difficulty of formulating rules for estimating reliability, the problem of assessing the reliability of any calculation which is to be put to practical use cannot be escaped. Any numerical value of unknown reliability is completely useless. This statement does not imply that all numerical values must be known with great precision, but rather that the confidence limits must be known. For example, if a calculation of the solubility loss in a precipitation process shows that 0.001 per cent of the desired constituent is not precipitated, and if it can be shown with reasonable confidence that the error in the calculation does not exceed two orders of magnitude, it is safe to conclude that solubility losses will be negligible (1 part per 1000 or less). However, if no confidence limits can be set, no conclusion whatsoever can be drawn.

Although it is not generally possible to formulate any numerical method for evaluating the reliability of an equilibrium calculation, it is possible to list the factors which must be considered in making such an evaluation. These factors may be grouped into four major categories, which are listed below as questions that must be answered in the process of evaluation:

(1) Does an equilibrium exist? That is, is the reaction reversible and are the rates of reaction sufficiently great to permit attainment of equilibrium in the time under consideration?

(2) Are there complicating secondary processes or "side reactions"? That is, can the system be defined in terms of a single, simple equilibrium, or must multiple equilibria and/or irreversible side reactions be considered also?

(3) Are the data necessary for the solution of the problem known with sufficient accuracy and precision?

(4) Are activity corrections either necessary or possible?

NONEQUILIBRIUM CONDITIONS

Obviously it is quite impossible to apply equilibrium calculations or equilibrium reasoning of any sort unless the first question can be answered in the affirmative. Despite the fact that many textbooks leave the student with the impression that nearly all of the reactions with which he is dealing are rapid and reversible, the fact is that many of the reactions of analytical interest are either slow or completely irreversible. Although examples of slow or irreversible processes can be cited for nearly every type of chemical reaction, such processes are most frequently encountered when dealing with oxidation-reduction or heterogeneous (*e. g.*, solubility, adsorption, etc.) equilibrium. The tendency to apply unjustified equilibrium reasoning to nonequilibrium processes is perhaps owing in part to the fact that standard potentials for irreversible redox couples and "equilibrium constants" for other irreversible reactions are frequently included in published tabulations of data. Such potentials and constants are usually calculated

* Presented at the 124th Meeting of the American Chemical Society, Chicago, September, 1953.

[1] EISEMANN, K., J. CHEM. EDUC., **26**, 607 (1949); K. J. RADIMER, *ibid.*, **27**, 251 (1950); D. D. DEFORD, *ibid.*, **27**, 554 (1950); R. N. BOYD, *ibid.*, **29**, 198 (1952); A. J. MCBAY, *ibid.*, **29**, 526 (1952); D. DAVIDSON AND K. GELLER, *ibid.*, **30**, 238 (1953); J. S. FRITZ, *ibid.*, **30**, 442 (1953).

from thermal data and are valuable in making thermochemical and certain other types of calculations, but they cannot be used in equilibrium reasoning.

Some examples will serve to illustrate the points outlined above. Of the many irreversible redox couples which are frequently encountered, the $Cr_2O_7^{--}:Cr^{+3}$, $SO_3^{--}:SO_4^{--}$, and $S_2O_3^{--}:S_4O_6^{--}$ couples are quite typical.[2] In each of these three couples, only the first species listed is active in establishing the potential of an indicator electrode immersed in a solution containing both oxidized and reduced species. For couples of this type the potential expression takes the form

$$E = E'_{ox} - (RT/nF) \log (ox)$$

or

$$E = E'_{red} + (RT/nF) \log (red)$$

rather than the usual Nernst expression. As an example of the very large error which arises when the Nernst equation (which presupposes a condition of equilibrium) is applied to calculation of potentials involving irreversible couples, the following problem may be cited: Calculate the oxidation potential of a system 0.0021 *M* in $Cr_2O_7^{--}$, 0.0042 *M* in Cr^{+3}, and 1.0 *M* in HCl. The calculated potential, employing a value of -1.33 v.[3] for the standard potential of the dichromate-chromic couple, is -1.35 v., while the experimental value is -1.00 v.[4]

The dichromate-chromic couple is irreversible not only with respect to the establishment of an electrode potential but also with respect to oxidation-reduction reactions. For example, experiments with radioactive tracers[5] have shown that dichromate and chromic ions do not exchange in the presence of iodide and hence that the oxidation of iodide by dichromate is an irreversible process. It is amply clear, therefore, that no type of equilibrium reasoning can be applied to irreversible couples of this type.

As an example of irreversible processes in solubility equilibrium, the precipitation of the sulfides of zinc, cobalt, and nickel may be cited. It is well known that the solubility products which are found in most tabulations lead to the prediction that these three elements should precipitate with the acid sulfide group in the conventional qualitative analysis scheme. Many explanations have been proposed for the fact that precipitation with this group does not occur. Probably the most reasonable explanation is based upon the evidence that each of these sulfides can exist in two or more solid modifications, each with a different solubility product. Three forms, α, β, and γ, of nickel sulfide, with solubility products given as equal to 3×10^{-21}, 1×10^{-26}, and 2×10^{-28}, respectively, have been suggested. The α form is precipitated in alkaline solution and is transformed irreversibly to the other forms on treatment with acid, thus explaining the fact that precipitation does not occur in acid solution but that the precipitate, once formed, will not dissolve in acid. There is also evidence that polysulfides are formed when cobalt and nickel are precipitated with sulfide in the presence of air, and that these polysulfides account for the insolubility of the precipitate in acid.[6] The fact that irreversible changes occur upon aging or ignition of other precipitates and that solubility equilibrium is often approached very slowly is well known and need not be discussed further here.

The formation of hexacyano complexes of ferrous and ferric iron, chromic chromium, and cobaltic cobalt may be mentioned as examples of irreversible complexation reactions. Although "dissociation constants" for these complexes may be found in many tabulations, the irreversible nature of the reactions is shown by the fact that radioactive cyanide exchanges only very slowly with the complexes.[7]

MULTIPLE EQUILIBRIA AND SIDE REACTIONS

Although most textbooks give some attention to multiple equilibria, particularly to equilibria involving polyfunctional acids and bases, there seems to be a general tendency to avoid this subject as much as possible. While it is admittedly difficult to extend equilibrium concepts to include multiple equilibria in an already crowded curriculum, the common occurrence of multiple equilibria demands that this subject be given more than passing mention. While the solution of problems involving multiple equilibria is more complex than those involving but a single equilibrium, the concepts are not beyond the grasp of chemistry undergraduates. Several of the papers listed in the first reference discuss possible approaches to the solution of problems of this type.

Multiple equilibria which involve nearly all conceivable combinations of simple equilibria are known. However, in order to keep the discussion of this subject within reasonable limits, only multiple equilibria that involve solubility-product equilibria are included in the examples which follow.

Some of the commonly occurring complications which are frequently associated with solubility-product equilibria include (1) the existence of more than one crystalline form of the solid, (2) the existence of more than one solid product (*e. g.*, basic salts or double salts along with normal salts), (3) mixed crystal formation, (4) adsorption and coprecipitation, (5) peptization of solids, (6) complex formation, and (7) hydrolysis or other types of

[2] Bezier, D., *Ann. chim. Paris* (11) **20**, 161 (1945). See also R. Gauguin, *ibid.*, (12) **4**, 832 (1949), and G. Emschwiller, *J. chim. phys.*, **47**, 184 (1950).

[3] Unless otherwise specified, all potentials and equilibrium constants employed in this paper are taken from W. M. Latimer, "The Oxidation States of the Elements and Their Potentials in Aqueous Solution," 2nd ed., Prentice-Hall, Inc., New York, 1952. The sign conventions used are also those used by Latimer.

[4] Smith, G. F., *Anal. Chem.*, **23**, 925 (1951).

[5] Muxart, R., P. Daudel, R. Daudel, and M. Haissinsky, *Nature*, **159**, 538 (1947).

[6] Donges, E., *Z. anorg. Chem.*, **253**, 345 (1947).

[7] Adamson, A. W., J. P. Welker, and M. Volpe, *J. Am. Chem. Soc.*, **72**, 4030 (1950).

acid-base equilibria. An example of the first member of this group has already been given in the preceding section.

Probably the formation of complexes is the most serious of the complicating factors in solubility product calculations. The data on the solubility of calcium oxalate [8] which are presented in Table 1 serve to illustrate

TABLE 1
Solubility of Calcium Oxalate in Ammonium Oxalate Solutions

$(NH_4)_2Ox$, M	Solubility ($M \times 10^6$) Calculated	Solubility ($M \times 10^6$) Measured
0	...	49.0
0.001	3.4	5.9
0.003	1.5	4.2
0.01	0.76	3.8
0.03	0.44	4.3
0.1	0.35	5.3
0.3	0.26	8.8

this point. In all cases the measured solubility in presence of excess oxalate is greater than that calculated from the solubility product. Furthermore, the "common ion effect" is operative only up to oxalate concentrations of about 0.01 M, where the solubility is a minimum. At an oxalate concentration of 0.3 M the solubility is more than thirty times the calculated value (neglecting complexation). A second example of this type is shown graphically in Figure 1, in which the solubility of silver chloride is plotted as a function of excess silver or chloride ion concentration. Although the agreement between the two sets of data [9,10] for the solubility in presence of excess chloride is not excellent, there is agreement within an order of magnitude or better, and both show the same general trend. Barney, Argersinger, and Reynolds found that their experimental data could be explained by postulation of the existence of the complex $AgCl_2^-$ with a dissociation constant of 2.2×10^{-6}. It should be noted that the solubility does not differ seriously from that predicted by the simple solubility product relationship for chloride ion concentrations up to about 10^{-3} M, but that the measured solubility in 1 M chloride is six orders of magnitude greater than that predicted by this simple relationship. In presence of excess silver ion, the increased solubility over that predicted by the solubility product principle is probably due in part to the formation of complex ions such as $Ag_2Cl_3^+$ and in part to peptization of the solid by the excess silver ion to form a colloidal silver chloride, which appears as "soluble." [11]

An example of an extremely complex precipitation process is afforded by the precipitation of ferric sulfate with sodium hydroxide. Ferric iron forms a complex, $FeSO_4^+$, with sulfate ion; the dissociation constant of this complex has been reported to be 9.4×10^{-3} at an ionic strength of one,[12] 1.04×10^{-3} at an ionic strength of 0.06,[13] and 1.5×10^{-4} at zero ionic strength.[12] Other sulfate complexes undoubtedly exist also. Ferric iron also forms the complexes $FeOH^{+2}$ and $Fe(OH)_2^+$ by reaction with water (hydrolysis); the formation constants of these complexes have been reported to be 1.25×10^{-3} and 4.2×10^{-4} respectively.[14] When sodium hydroxide is added to a ferric sulfate solution, no precipitate forms at first, but rather an unstable solution containing a variety of complex ions is obtained.[13] When the ratio of hydroxide to iron reaches about 0.5 a precipitate approximating the composition $2Fe_2O_3 \cdot SO_3 \cdot xH_2O$ forms. When the ratio reaches about 2.5, precipitation of the iron as the basic sulfate is complete. Addition of further hydroxide causes a slow conversion of the precipitate to the hydrous oxide. On long storage, solutions having ratios of hydroxide to iron of less than 0.5 deposit a precipitate approximating the composition $2Fe_2O_3 \cdot 5SO_3 \cdot yH_2O$. The absurdity of attempting equilibrium law calculations of almost any type on this system is quite apparent. Most of the precipitation processes involving hydrous oxides of other multivalent cations are equally complex.

It appears that nearly all cations of charge two or greater form complexes of significant stability with a large variety of common anions such as OH^-, SO_4^{--}, Cl^-, and SCN^-. There are very few data in the literature on the dissociation constants of these complexes, and furthermore such constants are very difficult to measure. Nevertheless, in many cases serious errors in computation of such quantities as solubility can result if these complexes are not considered. This subject has been reviewed recently by Young and Jones.[15]

[8] NYDAHL, F., *Acta Chem. Scand.*, **5**, 669 (1951).

[9] BARNEY, J. E., II, W. J. ARGERSINGER, JR., AND C. A. REYNOLDS, *J. Am. Chem. Soc.*, **73**, 3785 (1951).

[10] PINKUS, A., AND A. M. TIMMERMANS, *Bull. soc. chim. Belg.*, **46**, 46 (1937).

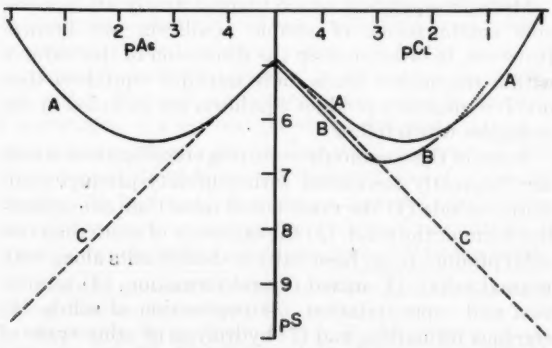


Figure 1. Solubility of Silver Chloride as a Function of Chloride and Silver Ion Concentrations

A, Measured solubility (PINKUS, ET AL., refs. 10, 11).
B, Measured solubility (BARNEY, ET AL., ref. 9).
C. Solubility calculated from solubility product.

[11] PINKUS, A., S. FREDERIC, AND R. SCHLEPMANS, *ibid.*, **47**, 304 (1938).

[12] WHITEKER, R. A., AND N. DAVIDSON, *J. Am. Chem. Soc.*, **75**, 3081 (1953).

[13] SYKES, K. W., *J. Chem. Soc.*, **1952**, 124.

[14] ARDEN, T. V., *J. Chem. Soc.*, **1951**, 330.

[15] YOUNG, T. F., AND A. C. JONES, *Ann. Rev. Phys. Chem.*, **3**, 275–308 (1952).

Data which have been accumulated through studies with radioactive tracers during the last forty years show that macroscopic laws (including the equilibrium law) frequently do not apply at concentrations of the order of 10^{-7} M or less. The failure of these laws at very low concentrations is almost universal in heterogeneous systems involving solids. Since all practical systems are heterogeneous in that walls of containers and dust particles are in contact with solutions, it appears that little, if any, significance can be attached to calculated concentrations much less than $10^{-7}M$ in most cases. For example, the solubility of lead sulfide in pure water, calculated from the solubility product (7×10^{-29}) alone is of the order of 10^{-14} M. If hydrolysis of the sulfide ion is considered and corrected for in making the calculation, the calculated solubility is of the order of 10^{-10} M. The measured[16] solubility is reported to be 1.3×10^{-6} M. The solubility of mercuric sulfide in 1 M perchloric acid saturated with hydrogen sulfide, calculated on the basis of the solubility product (1.6×10^{-54}) alone, is of the order of $10^{-32}M$. If the formation of the complex ion HgS_2^{--}, with a dissociation constant of 2×10^{-55}, is considered in making the calculation, the calculated solubility is still only of the order of 10^{-21} M. The measured[17] solubility is reported to be 3.3×10^{-7} M. Some of the properties of solutions containing very small concentrations of certain ions have been summarized in recent papers by Haissinsky[18] and by Schweitzer and Jackson.[19]

An excellent discussion of the solubility problem in analytical chemistry, not only with respect to multiple equilibrium and side reactions but also with respect to irreversible and slow reactions and to reliability of data, has been given by McAlpine and Soule.[20]

RELIABILITY OF DATA

The uncertainties associated with equilibrium constants which have been reported in the literature range from a few per cent or even less in some cases to many orders of magnitude in other cases.

Generally speaking, the dissociation constants of weak acids and bases in an aqueous solvent can be measured with high precision, but even for this type of equilibrium discordant values are not infrequently reported by different investigators. For example, a recent determination[21] of the dissociation constant of boric acid yielded a value of 2.9×10^{-10}. An earlier determination[22] yielded a value of 5.8×10^{-10}. The latter value is the one included in the tabulations found in most textbooks, but a value of 1.1×10^{-9} is listed in at least two popular texts.[23, 24] In this connection it should be mentioned that both the measurement of this dissociation constant and its application are complicated by the fact that boric acid tends to form polymeric species.

Discrepancies of many orders of magnitude between the values obtained by different investigators for solubility products are not uncommon. A recent determination[25] of the solubility product of ferrous hydroxide yielded a value of 8×10^{-16}. Twelve previously reported values for this constant ranged from 7×10^{-13} to 4.5×10^{-21}. Goates, Gordon, and Faux[26] have recently recalculated and tabulated values for the solubility products of a number of metal sulfides. Their values differ by factors as large as 10^5 from values tabulated in most textbooks.

It is clear from the examples cited above that tabulations of values of equilibrium constants are of very limited value unless the tabulation includes also some indication of the reliability of each of the values reported. If it is impossible to select a single "best" value from a number of discordant values, it would appear advisable to tabulate all of the most reliable values reported. It is imperative that the student be apprised in some manner of the reliability of the data upon which his calculations and conclusions are based.

ACTIVITY CORRECTIONS

Many of the more recent textbooks of quantitative analysis include more or less complete discussions of the activity concept and include the use of activity corrections in solving equilibrium problems. While the introduction of the activity concept appears to be desirable, it should be emphasized that activity corrections are justified only if it can be shown that the reactions involved are rapid and reversible, that complicating side reactions are either absent or properly included in the calculation, and that the constants necessary for the solution of the problem are truly thermodynamic values of high precision and accuracy. Actually, only a small fraction of the problems of practical interest satisfy these criteria. Furthermore, it is pointless to include activity corrections unless the problem requires a precise numerical answer. Acid-base equilibria are usually more susceptible to highly precise calculations than any other type of equilibrium; it would appear that the activity concept can be best introduced and illustrated in connection with the study of this type of equilibrium.

The data on individual activity coefficients that have been summarized by Klotz[27] seem to be convenient, re-

[16] Hevesy, G., and F. Paneth, *Z. anorg. Chem.*, **82**, 322 (1913).
[17] Treadwell, W. D., and F. Schaufelberger, *Helv. Chim. Acta*, **29**, 1936 (1941).
[18] Haissinsky, M., *Bull. soc. roy. sci. Liège*, **20**, 591 (1951).
[19] Schweitzer, G. K., and M. Jackson, J. Chem. Educ., **29**, 513 (1952).
[20] McAlpine, R. K., and B. A. Soule, "Qualitative Chemical Analysis," D. Van Nostrand Co., Inc., New York, **1933**, pp. 87–137.
[21] Edwards, J. O., *J. Am. Chem. Soc.*, **75**, 6151 (1953).
[22] Owen, B. B., *ibid.*, **56**, 1695 (1934).
[23] Pierce, W. C., and E. L. Haenisch, "Quantitative Analysis," 3rd ed., John Wiley & Sons, Inc., New York, **1948**.
[24] Hogness, T. R., and W. C. Johnson, "Qualitative Analysis and Chemical Equilibrium," Revised ed., Henry Holt and Co., New York, **1940**.
[25] Leussing, D. L., and I. M. Kolthoff, *J. Am. Chem. Soc.*, **75**, 2476 (1953).
[26] Goates, J. R., M. B. Gordon, and N. D. Faux, *J. Am. Chem. Soc.*, **74**, 835 (1952).
[27] Klotz, I. M., "Thermodynamics," Prentice-Hall, Inc., New York, **1952**.

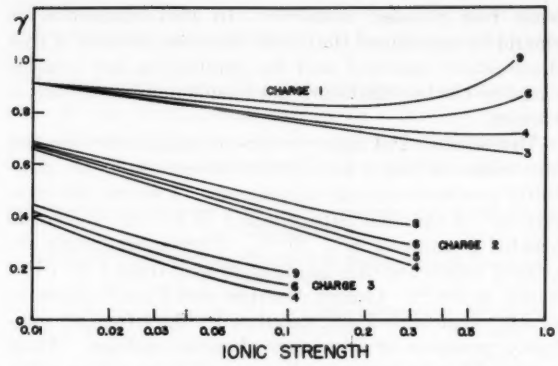


Figure 2. Activity Coefficients of Ions as a Function of Ionic Strength (Logarithmic Scale)

liable, and fairly complete. A small portion of his tabulation of ionic diameters is given in Table 2, and activity coefficients as a function of ionic strength for various charge types and ionic diameters are shown graphically in Figure 2. The tables given by Klotz go up to ionic strengths of only 0.1; values at higher ionic strengths are average values calculated from the data summarized by Latimer.[3] With these activity data it is a very simple matter to determine appropriate activity corrections and to include these corrections in any calculation.

The precise calculation of the pH of a solution that is 0.025 *M* in potassium dihydrogen phosphate and 0.025 *M* in disodium hydrogen phosphate at 25°C. will serve to illustrate a computation which justifies the use of activity corrections. The equilibrium of concern in this problem is

$$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{--}$$

and the equilibrium constant expressions are

$$K = \frac{a_{H^+}\, a_{HPO_4^{--}}}{a_{H_2PO_4^-}};\quad a_{H^+} = K\frac{a_{H_2PO_4^-}}{a_{HPO_4^{--}}} = K\frac{c_{H_2PO_4^-}\ \gamma_{H_2PO_4^-}}{c_{HPO_4^{--}}\ \gamma_{HPO_4^{--}}}$$

The concentration of both the dihydrogen phosphate ion and the monohydrogen phosphate ion is 0.025 *M* from the data given. The ionic strength of the solution is 0.100. The effective diameters of both ions is found to be 4 from Table 2. The activity coefficients of the dihydrogen and monohydrogen phosphate ions are then found to be 0.77 and 0.355, respectively, from Figure 2. The value of *K* is 6.2×10^{-8}. When these data are substituted into the equation, the activity of the hydrogen ion is found to be 1.36×10^{-7}; hence the pH is 6.87. The experimentally determined[28] pH is 6.86. If activity corrections are neglected the calculated pH is 7.21. Obviously a considerably better value is obtained if activity corrections are applied. In general it is possible to calculate pH values that are within a few hundredths of a pH unit of the measured values for aqueous acid-base systems which are not complicated by secondary reactions, which have ionic strengths not greatly exceeding 0.10, and for which reliable dissociation constants are available. Calculated values frequently are in error by several tenths of a unit if activity corrections are neglected.

[28] A.S.T.M. Tech. Publ. No. 73, 31–63 (1946).

CONCLUSIONS

A variety of examples have been presented to illustrate errors which may arise in making calculations based upon the equilibrium law. The frequent occurrence of these errors in solving problems of practical interest in analytical chemistry makes it imperative that the student be acquainted with the limitations as well as the legitimate applications of this law. Instructors must exercise care in selecting assigned problems to be sure that the calculated answers are in reasonable agreement with experimental facts. Students must be taught to make sure than an equilibrium exists before attempting to apply the law. The frequent complications arising from secondary reactions and multiple equilibria must be pointed out, and if time permits, the student should be taught the general principles of solving problems involving several equilibria. Although the student in elementary courses in analytical chemistry is not usually capable of evaluating the reliability of published data or of selecting the best values from sets of discordant data, he should be acquainted with the fact that unreliable and discordant data are frequently found in the literature and should be taught to evaluate his answers accordingly. Finally, in all but the very short courses in quantitative analysis it would appear desirable to introduce the activity concept and to include calculations involving activity corrections. However, activity corrections should be attempted only when the nature of the equilibrium and the reliability of the data warrant a precise calculation and only when a precise answer is necessary to solve the problem at hand.

TABLE 2

Effective Diameters of Hydrated Ions in Aqueous Solution

$a \times 10^8$	*Singly Charged Ions*
9	H^+
6	Li^+, $C_6H_5COO^-$
4–4.5	Na^+, HCO_3^-, $H_2PO_4^-$, HSO_3^-, $H_2AsO_4^-$, CH_3COO^-, $(CH_3)_4N^+$
3.5	OH^-, F^-, NCS^-, HS^-, $HCOO^-$, $H_3Citrate^-$
3	K^+, Cl^-, Br^-, I^-, CN^-, NO_3^-
2.5	NH_4^+, Tl^+, Ag^+
	Doubly Charged Ions
8	Mg^{++}
6	Ca^{++}, Cu^{++}, Zn^{++}, Fe^{++}, $C_6H_4(COO)_2^{--}$
5	Sr^{++}, Ba^{++}, Cd^{++}, S^{--}, $H_2C(COO)_2^{--}$, $(CH_2COO)_2^{--}$
4.5	Pb^{++}, CO_3^{--}, $(COO)_2^{--}$, $HCitrate^{--}$
4	SO_4^{--}, CrO_4^{--}, HPO_4^{--}
	Triply Charged Ions
9	Al^{+3}, Fe^{+3}, Cr^{+3}, Ce^{+3}
5	$Citrate^{-3}$
4	PO_4^{-3}, $Fe(CN)_6^{-3}$, $CO(NH_3)_6^{+3}$

INDETERMINATE ERROR ESTIMATES FROM SMALL GROUPS OF REPLICATES

RALPH A. JOHNSON
University of Illinois, Urbana, Illinois

THE discussion of errors has become a regular part of instruction in quantitative analysis. Two categories of errors are generally given: determinate and indeterminate. Discussion of the determinate errors fits smoothly into the discussion of chemical subject matter; for example, the principles of equilibrium and stoichiometry are applied in estimating the titration and solubility errors. Further, the determinate error concept is a concrete one. It requires little imagination to realize that the true value may not be the nominal value of a weight or buret graduation and that calibrations correct this error. The discussion of indeterminate, or variable error, is not so well favored. Its meaning is not simply established through an extension of familiar chemical calculations. It cannot be "pinned down" and clearly and simply viewed as a physical defect. Its inevitability and unpredictability are philosophically incompatible with the scientific exactness implicit in discussing elementary chemical theory and making the related chemical calculations.

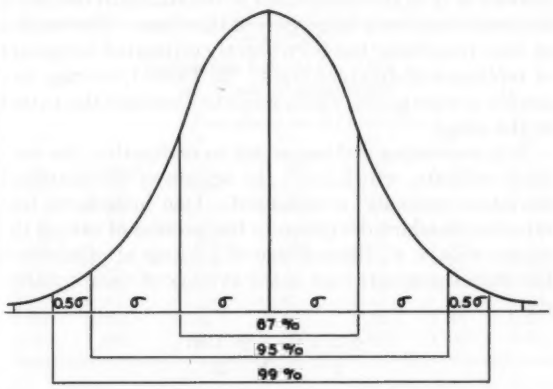


Figure 1. The Normal Distribution Showing Cumulative Frequencies as a Function of Standard Deviation

For the indeterminate error, the learning situation is created in the laboratory. Having found results differing among chemical analysts in spite of their applying the utmost in care and skill, the initiate to chemical analysis is eager to accept a category of errors that are always present and are simply a matter of chance. The temptation now comes to relieve one's self of all responsibility, to proceed deliberately through the ritual of the analysis, and leave the outcome to chance. A satisfactory approach to this kind of error requires, first, imagination to achieve a realistic, qualitative concept of it and, second, the discipline of statistics to define it quantitatively and supply the mechanism for its interpretation and application. There is a growing recognition of the indeterminate error as an attribute which can be measured and clearly described. Although experienced experimentalists intuitively appraise their indeterminate error estimates quite accurately, the statistical approach gives uniformity and system to this highly important operation. Statements of standard deviation or fiducial limits and the number of measurements contributing to these estimates are replacing such vague statements as, "The method is good to two per cent," or, "Results agree within three parts per thousand." With definite statements of the indeterminate error at hand, more realistic evaluations of and comparisons between the methods and instruments of chemical measurement can be made.

Application of the reproducibility[1] estimate is often illustrated by describing it to be a measuring stick for laying off probability regions under the normal distribution curve as in Figure 1. For example, 95 per cent of the measurements deviate from the mean by less than 2 σ and a result deviating by more than 2.5 σ will occur by chance only once in approximately one hundred times.

Although statistics is now more widely and more correctly used than ever before, there is still some misunderstanding of the subject. The budding chemist will not venture far into the world of his profession before being faced with the proposition that "statistics are not applicable to small groups of data." If the statement is understood to be general, statistics may easily come to be regarded as irrelevant to most chemical analyses or as a form of applied witchcraft used specially to dignify poor data. A more thorough analysis of the situation recognizes that classical statistics fails in certain respects when applied to small groups of replicates. However, it carefully defines the nature of the failure and reveals that procedures are available which take proper account of the number of replicates available. It is the general purpose of this paper to make this analysis. It is its specific purpose to evaluate the statistics used to estimate the indeterminate error. It assumes knowledge of classical statistics of normal distributions as described in elementary textbooks of quantitative analysis.

[1] The term reproducibility is preferred to precision in this sense because the former has greater semantic value and is less ambiguous. *Cf.* definition of precision in "Webster's Collegiate Dictionary," G. and C. Merriam Co.

The behavior of reproducibility estimates may be illustrated by an imaginary experiment. It is supposed that a million chloride analyses are carried out on a given sample and that the variation of the results follows a normal distribution. From this very large group of data, a standard deviation is calculated. If another large set of replications is done, the new standard deviation virtually coincides with its counterpart in the first group. It is important to recognize that the estimate of reproducibility, *i. e.*, the standard deviation, is itself so reproducible when derived from so large a population as a million that it may be regarded as a single-valued attribute of the analysis. It is accordingly termed the universe standard deviation and designated as σ. A standard deviation so obtained is a reliable measuring stick for laying off probability regions. It is this situation that is treated in classical statistics.

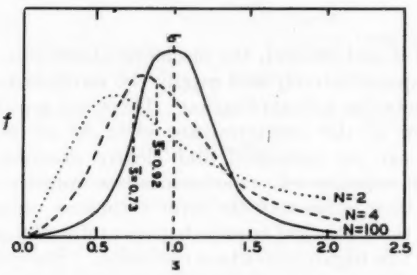


Figure 2. Distribution of Standard Deviation Estimates (s) from a Population with $\sigma = 1$

Because of time limitations, most measurements in chemistry are limited to two to ten replications. How do these standard deviation estimates compare in magnitude with the universe standard deviation? How do the small-group estimates agree among themselves? For the answers to these questions a new model is set up: the data from the chloride analyses previously carried out are randomly separated into groups of ten, and standard deviations are calculated for each group. The chemist now inspects the resulting array of standard deviations in search of an index to the indeterminate error of his method. His first general impression is that standard deviations from small groups of replicates are not exact; they are hardly well defined measuring sticks for use in probability estimations. To distinguish them as approximations of their single-valued counterpart, σ, they are termed standard deviation *estimates* and are symbolized by s. Upon further analysis, he realizes as significant two characteristics of the behavior (or misbehavior) of the small sample statistics: (1) the estimates are not single-valued. They vary on either side of the universe value, σ, as shown in Figure 2. Further, as the number of replicates decreases, the proportion of *very* high and *very* low results becomes greater. (2) The deviation estimates tend to be low and the discrepancy increases as fewer replicates are involved. This tendency is manifest in two ways: (*a*) low values appear more frequently than high values, and (*b*) the over-all average is less than σ. The concentration of values on the low side is indicated in Figure 2. A tendency of a statistic to deviate more in one direction than another is called *bias*. (Note that this bias is not a subjective matter.) For standard deviation estimates, the bias is negative.

TABLE 1
Factors for Bias Correction for Standard Deviation Estimates

N = no. of replicates; $c = \frac{\sigma}{s}$

N	c	N	c
2	1.375	10	1.028
3	1.128	15	1.018
4	1.085	25	1.010
5	1.064	50	1.005
6	1.051	100	1.002
8	1.036		

With this general survey and analysis of the behavior of reproducibility estimates at hand, the chemist is prepared to face a small group of replicates encountered in one of his everyday analytical problems and make some specific inferences about the indeterminate error therein represented. In the remainder of this paper, three such inferences are given along with some detailed background for making them quantitative.

(1) A reproducibility estimate is, on the average, low, *i. e.*, it has a negative bias, and the bias increases as the number of replicates decreases. The use of $N - 1$ instead of N in the calculation of the standard deviation estimate removes a large part of this bias. The residue of bias remaining has been exactly estimated for groups of replicates of different sizes. In Table 1, average values for σ/s are given, which serve to illustrate the extent of the effect.

It is interesting and important to realize that the variance estimate, which is s^2, the square of the standard deviation estimate, is unbiased. One introduces bias into the standard deviation in the process of taking the square root, *i. e.*, the average of a group of numbers is less than the square root of the average of their squares, *e. g.*,

$$\frac{2+4}{2} < \sqrt{\frac{2^2+4^2}{2}}$$

The variance is the key statistic in the powerful modern statistical methods rapidly gaining popularity in chemical experimentation. It is understandable then that professional statisticians deplore the practice of taking the square root of this key statistic. They hope that experimentalists will realize the special convenience of this statistic and will become so accustomed to it that it will become the customary form for reporting the indeterminate error.

It is also interesting to note that unbiased estimates of average deviation may be produced by simply using $\sqrt{N(N-1)}$ instead of N as the divisor. However, though this statistic can be easily obtained bias-free, it has serious limitations, "limitations that are a heavy

price to pay for a measure of reproducibility that has as its only asset its ease of computation."[2]

(2) Reproducibility estimates vary on either side of the true value, extreme values becoming more frequent as the number of replicates decreases. This kind of variation may be evaluated graphically by a frequency distribution plot as in Figure 2, or it may be presented by a statement of *confidence limits*. Confidence limits relate definite values of the statistic in question to stated probability levels (percentiles). For example, 10 per cent of standard deviation estimates from groups of 10 replicates are less than 70 per cent as large as σ and 10 per cent of these estimates are more than 125 per cent of the universe value. The variability increases sharply as the size of groups decreases below 10: For groups of three replicates, s at the tenth percentile is less than one-third σ and at the ninetieth percentile it is more than one and a half times as great as σ. Confidence limits may be symbolically represented by the letter l with the probability level as a subscript, *e. g.*, for standard deviation estimates from groups of three,

$$l_{0.10} = 0.32\ \sigma; \qquad l_{0.90} = 1.51\ \sigma$$

Factors relating s^2 to σ^2 are called χ^2/d. f. (chi-square over degrees of freedom). Tables of "percentiles of the χ^2/d. f. distribution" are readily available and may be used to compute confidence limits for variances. Square roots of the factors serve for similarly treating standard deviations. Some representative values are given in Table 2.

TABLE 2
Confidence Limits for s if $\sigma = 1$
N = no. of replicates

	Probability levels (percentiles)					
N	*1*	*5*	*10*	*90*	*95*	*99*
2	0.013	0.031	0.126	1.65	1.96	2.58
3	0.10	0.227	0.324	1.52	1.73	2.15
4	0.20	0.342	0.442	1.44	1.61	1.94
5	0.27	0.422	0.516	1.39	1.54	1.82
6	0.33	0.478	0.568	1.36	1.49	1.74
8	0.42	0.557	0.636	1.31	1.42	1.62
10	0.48	0.61	0.68	1.28	1.37	1.55
25	0.67	0.76	0.81	1.17	1.23	1.34
60	0.79	0.85	0.88	1.11	1.15	1.21
∞	1.00	1.00	1.00	1.00	1.00	1.00

Estimates of average deviation are somewhat less reproducible than estimates of standard deviation. The ratio of the variances of these two estimates is called the efficiency. It is noted in passing that the efficiency of the average deviation decreases as the number of replicates decreases. A good discussion of thi scomparison is given by Dixon and Massey.[3]

(3) In the third inference, an estimate of the indeterminate error in terms of the mean of the replicate group, $\bar{\chi}$, is derived from the standard deviation estimate, s. In this respect, it is an extension of the second inference. The device of confidence limits is again employed and upper and lower limits of $\bar{\chi}$ corresponding to definite probability levels are set. The key to computation of these limits is the statistic t, defined as

TABLE 3
Values of t (Sign Ignored)
d. f. = degrees of freedom = $N - 1$

	Probability levels		
d. f.	*0.1*	*0.05*	*0.01*
1	6.31	12.71	63.7
2	2.92	4.30	9.93
3	2.35	3.18	5.84
4	2.13	2.78	4.60
5	2.02	2.57	4.03
10	1.81	2.23	3.17
25	1.71	2.06	2.79
60	1.67	2.00	2.66
∞	1.64	1.96	2.58

$\bar{\chi} - \mu/s_{\bar{\chi}}$, where μ is the true, or universe mean and $s_{\bar{\chi}}$ is the estimate of standard deviation of the mean derived from the estimated s in the usual way,

$$s_{\bar{\chi}} = \frac{s}{\sqrt{N}}$$

where N is the number of replicates. A clue to the behavior of t is gained from the sampling of chloride replicates previously described. There it was observed that very small values of s occur more frequently as the respective number of replicates decreases. Correspondingly, t-values calculated from small groups of these replicates present very high values with greater frequency as the respective number of replicates decreases; or, stated conversely, at any given probability level, t-values increase with decreasing number of replicates. Note that when the number of replicates is very large, $s_{\bar{\chi}}$ approaches $\sigma_{\bar{\chi}}$ and bears a relationship to the distribution of $\bar{\chi}$ described by classical statistics of normal distributions, *e. g.*, 95 per cent of $\bar{\chi}$'s fall within the limits $\mu \pm 1.96\ \sigma_{\bar{\chi}}$. For any small group of replicates, the appropriate t-value and respective s-estimate replace 1.96 σ, and confidence limits, l_p, are calculated from

$$l_p = \mu \pm t_p s$$

A representative list of t-values is given in Table 3.

It is noted in passing that methods involving the statistic t are examples of a system of statistics that is finding more and more application in the planning of efficient experiments and realistic interpretation of results. The fundamental deviation estimate in these new systems is the standard deviation, or its square, the variance.

CONCLUSIONS

(1) The nature of the indeterminate error, particularly its inevitability and unpredictability, makes it a more difficult concept than the determinate error.

[2] Youden, W. J., "Misuse of the standard deviation," *Nat. Bur. Standards U. S., Tech. News Bull.*, **34** (Jan., 1950).

[3] Dixon, W. J., and F. J. Massey, Jr., "Introduction to Statistical Analysis," McGraw-Hill Book Co., Inc., New York, 1951.

(2) Statistics defines the concept quantitatively and provides the mechanism for its interpretation and application.

(3) The indeterminate error can be represented by a standard deviation estimate, s. As fewer replicates are used to form this estimate, the estimate (*a*) becomes less reproducible, (*b*) tends on the average to give lower results (bias), and (*c*) represents a greater frequency of low results.

(4) It is proper to report the number of replicates or degrees of freedom contributing to a standard deviation estimate. This permits evaluation of the estimate against a background of the known behavior of this statistic. With the number of replicates given, the informed reader can make realistic inferences about the reliability and bias of the estimate.

(5) For reporting the indeterminate error, standard deviation is superior to average deviation with respect to bias and reproducibility. It is also to the credit of the standard deviation that it can be used directly, or by simply squaring it to form the variance, in the powerful modern statistical methods so useful in scientific experimentation. From the statistical point of view, the variance is preferred to the standard deviation.

(6) The indeterminate error can also be represented by confidence limits of the mean, calculated from the statistic t. This estimate is unbiased. It is proper to report also the number of replicates or degrees of freedom contributing to the estimate.

ACKNOWLEDGMENT

This will acknowledge with appreciation the helpful criticisms of Dr. H. W. Norton, Professor of Agricultural Statistics, University of Illinois, who read the manuscript, for his numerous discussions and valuable suggestions for its revision.

ORGANIC QUANTITATIVE ANALYSIS

JAMES S. FRITZ
Iowa State College, Ames, Iowa

DEVELOPMENT of the products of organic chemistry has been tremendous in recent years. Synthetic drugs, fabrics, rubber, detergents, plastics, insecticides, paints, and many others are in constant evidence in our daily lives. Manufacture of these products requires extensive analytical control. Especially with so many new products and processes, the analytical chemist is continually faced with new problems. The accompanying expansion of pure chemical research on organic compounds has also presented many analytical problems. It therefore follows that the quantitative analysis of organic matter is now a big problem and an important one.

One definite trend in analysis of organic matter is the ever increasing use of spectrophotometric methods. Infrared methods have achieved greatest distinction in the qualitative organic field but quantitative applications are increasing. Visual and ultraviolet methods are very useful for trace analysis of both organic and inorganic constituents.

Also important is the greater recognition of the value of functional group analysis. Such methods often permit direct determination of a specific compound in an organic mixture without a preliminary separation.

Quantitative methods for functional groups are usually much quicker and less tedious than organic elemental analysis procedures. Advantages of this approach to quantitative organic analysis have been pointed out in a convincing manner by Siggia (*1*, *2*).

Another technique which is now assuming considerable importance is the titration of organic acids and bases in nonaqueous solvents. Although the history of such analytical methods goes back at least to 1903 (*3*), a large part of the work in this field has been done very recently. Because this topic is newer and perhaps less familiar to educators than colorimetric and functional group analytical methods, a brief review might be in order.

ACID-BASE TITRATIONS: LIMITATIONS IN AQUEOUS SOLUTION

The scope of acid-base titrations in water or in water-alcohol solution is limited. Bases having a pK_b and acids having a pK_a greater than 6 or 7 are too weak to be accurately titrated. Several important classes of compounds, including aromatic amines, nitrogen heterocyclic compounds related to pyridine, enols, imides, and phenols, fall into the group that is too weakly basic or acidic to be titrated in water. All of these, however, can be accurately titrated in the proper nonaqueous solvents. Present techniques for nonaqueous titrations will in general permit the titration of bases having a

pK_b value (in water) of less than 13 and of acids of pK_a (in water) less than about 11.

TITRATION OF BASES: THEORETICAL CONSIDERATIONS

For titration of organic bases, glacial acetic acid is the most widely used nonaqueous solvent. Perchloric acid in glacial acetic acid is employed as the titrant. The end point can be detected either by the use of methyl violet indicator, or potentiometrically using an ordinary pH meter or other direct reading potentiometer. Traces of water can be tolerated but the concentration of water present should be kept at a minimum.

The following reactions, written in the Brönsted form, show why acetic acid is preferred to water or alcohol as a medium for the titration of weak bases:

	(*acid*)		(*base*)		(*acid*)		(*base*)
In water:	H_3O^+	+	B	=	BH^+	+	H_2O
In acetic acid:	H_2Ac^+	+	B	=	BH^+	+	HAc

Since the solvent is present in tremendous excess in comparison to the other species present, the basic properties of water are sufficient to partially reverse the above reaction near the stoichiometric point, causing a poor end point. Acetic acid is almost completely lacking in basic properties; hence the end point is more likely to be sharp.

In water, hydrochloric, perchloric, or nitric acid will serve equally well from the standpoint of acid strength for the titration of bases. These acids are intrinsically of different acid strength but water has sufficient basic strength to neutralize them partially. In each case the weaker acid, H_3O^+, is formed quantitatively.

$$HClO_4 + H_2O \rightarrow H_3O^+ + ClO_4^-$$
$$HCl + H_2O \rightarrow H_3O^+ + Cl^-$$
$$HNO_3 + H_2O \rightarrow H_3O^+ + NO_3^-$$

This has been referred to as the "leveling effect" (*4*). Acetic acid does not possess the basic strength to react completely with any of the above acids; hence in this solvent they do not have equal acid strength. In acetic acid the order of acid strength is perchloric > hydrochloric > nitric (*5*). For this reason perchloric acid is almost always used to titrate bases in nonaqueous solvents.

TITRATION OF BASES—SCOPE

Total amines can be determined by titration in acetic acid. Aliphatic amines, amino acids, aromatic amines, and basic nitrogen heterocyclic compounds can be titrated. Amides, certain negatively substituted amines such as 2,4-dinitroaniline, and various other very weak bases cannot be determined.

Amine and alkali metal salts of carboxylic and most mineral acids can be titrated. In order to determine amine hydrohalides, excess mercuric acetate is first added to combine with the halide ion.

$$2RNH_3^+X^- + HgAc_2 \rightarrow 2RNH_3^+Ac^- + HgX_2$$

The amine acetate can then be titrated with perchloric acid (*6*).

$$RNH_3^+Ac^- + HClO_4 \rightarrow RNH_3^+ClO_4^- + HAc$$

Mercuric acetate is not dissociated in acetic acid; hence a slight excess does not interfere.

It is possible to determine quantitatively tertiary amines in a mixture by a preliminary acetylation. The basic properties of primary and secondary amines are largely destroyed while those of the tertiary amines are not affected. When acetylation is complete, acetic acid is added and tertiary amines are titrated with perchloric acid without removing the excess acetic anhydride.

Differential titration of aromatic-aliphatic amine mixtures is also useful. Acetic acid is a leveling solvent for most amines, however, and only one end point is obtained. If a nonacidic (and therefore nonleveling) solvent such as acetonitrile is used, separate end points are obtained for aliphatic and aromatic amines (*7*).

TITRATION OF ACIDS

In order to titrate a weak acid, the solvent used should not possess acidic properties and the titrant used should be as strong a base as possible. The most generally useful conditions are:

Solvent: Dimethylformamide, ethylenediamine, or butylamine.
Titrant: Potassium methoxide in benzene-methanol (*8*) or sodium aminoethoxide in ethanolamine-ethylenediamine (*9*).
Indicators: Thymol blue, azo violet, *o*-nitroaniline, or potentiometric indication of the end point.

The table outlines the scope of organic compounds which can be titrated as acids. Further details are contained in a recent monograph (*10*).

STUDENT EXPERIMENTS

Titrations in nonaqueous solvents lend themselves well to student experiments in both elementary and advanced courses. The methods illustrated are of important practical value. Also, most students are considerably intrigued at the idea of doing a titration in some solvent other than water. This topic also presents an excellent opportunity to review the various acid-base theories. Suggested unknowns are:

(*a*) Titration of an amine in glacial acetic acid. It is convenient to dispense unknowns as glacial acetic acid solutions of an amine.

(*b*) Neutral equivalent of carboxylic acid, enol, or imide. This is done by titration in dimethylformamide with potassium methoxide using thymol blue or azo violet indicator.

(*c*) Tertiary amines in a mixture by acetylation and perchloric acid titration. It is recommended that the titration be carried out potentiometrically.

ORGANIC ANALYSIS AND THE CHEMISTRY CURRICULUM

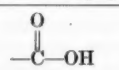
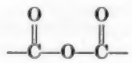
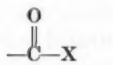
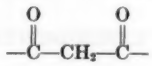
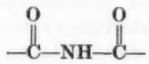
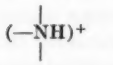
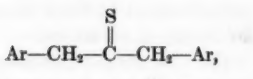
For the most part, quantitative analysis of organic material has been almost completely neglected by the colleges and universities. In a paper entitled, "The training of analytical chemists for industrial research," Stillman (*11*) has criticized this attitude:

To many educators analytical chemistry has meant systematic inorganic chemistry. The subject of analysis of organic compounds has been treated somewhat incidentally along with the study of organic chemistry. This has tended to minimize the importance of organic analysis at a time when, if anything, it should be receiving more emphasis than inorganic analysis because of the rapid expansion of the synthetic organic chemical field. Organic analysis should be treated as an integral part of analytical chemistry, and the principles to be applied should be studied alongside those of inorganic analysis.

This comment is from an industrial research chemist. However, the chemistry professor is likely to ask how more material can be added to courses already crowded with subject matter. I would like to suggest a re-evaluation of the topics commonly included in undergraduate quantitative analysis. Perhaps some are no longer worth the time and emphasis commonly accorded them.

In order to get an up-to-date idea of the relative importance of various methods of analysis, a survey was made of papers published in *Analytical Chemistry* during 1952. Only papers dealing with methods of analysis were classified; general reviews and papers dealing with construction of apparatus and instruments or dealing with the determination of physical constants were not included. While the number of research papers published on a method may not be a precise measure of its importance and incidence of use, it should at least give a semiquantitative measure.

Some Functional Groups Which Can Be Titrated as Acids

Name	*Type formula*
Carboxylic acid	
Carboxylic acid anhydride	
Carboxylic acid halide	
Enol	
Imide	
Phenol	Ar—OH
Salts	
Sulfonamide	Ar—SO_2—NH—
Miscellaneous	

Of 373 papers and notes classified, 56 per cent dealt with analysis of organic matter while 44 per cent were concerned with inorganic analysis. The methods used in both organic and inorganic analysis were classified as follows:

Colorimetric (Visual, ultraviolet, infrared)	35%
Titrimetric (Indicators, potentiometric, amperometric, coulometric, conductometric, etc.)	25%
Instrumental (Methods not included in colorimetric or titrimetric classification: polarographic, mass spectrophotometric, X-ray, etc.)	16%
Gravimetric (Including gravimetric elemental organic methods)	9%
Miscellaneous	15%

To me, these data suggest the following conclusions:

(1) Organic analysis is now approximately equal in importance to inorganic analysis and should therefore be introduced into the elementary quantitative analysis course. As Elving has pointed out (*12*), the approach to organic analysis is different from inorganic analysis and training limited to inorganic methods does not adequately prepare a student to do organic analytical work.

(2) Gravimetric analysis no longer warrants the large amount of time usually spent on it, especially in the laboratory course. Too much emphasis on repetitious gravimetric exercises accomplishes little and often makes the student thoroughly disgusted with analytical chemistry. Other experiments should be just as effective in teaching the necessity for precision and careful technique.

(3) The tremendous importance of colorimetric methods in both organic and inorganic analysis makes adequate instruction in such methods necessary. Too often this topic is either quickly passed over or omitted altogether. Instruction should not be limited to colorimetry as carried out in Nessler tubes or with a Duboscq colorimeter, but should include elementary spectrophotometry.

(4) Organic chemistry (preferably one year) should be taken before beginning quantitative analysis. This reverses the usual sequence but several schools have found it practicable. Because of the importance of organic precipitants, color-forming reagents, and solvents for extraction, it has become difficult to teach even a modern course in *inorganic* analysis without some knowledge of organic chemistry on the student's part.

LITERATURE CITED

(1) Siggia, S., J. Chem. Educ., **27**, 141 (1950).
(2) Siggia, S., *Anal. Chem.*, **23**, 667 (1951).
(3) Vorländer, D., *Ber. deut. chem. Ges.*, **36**, 1485 (1903).
(4) Hantzsch, A., *Z. physik. Chem.*, **134**, 406 (1928).
(5) Kolthoff, I. M., and A. Willman, *J. Am. Chem. Soc.*, **56**, 1007, 1014 (1934).
(6) Pifer, C. W., and E. G. Wollish, *Anal. Chem.*, **24**, 300 (1952).
(7) Fritz, J. S., *ibid.*, **25**, 407 (1953).
(8) Fritz, J. S., and R. T. Keen, *ibid.*, **25**, 179 (1953).
(9) Moss, M. L., J. H. Elliott, and R. T. Hall, *ibid.*, **20**, 784 (1948).
(10) Fritz, J. S., "Acid-Base Titrations in Nonaqueous Solvents," G. F. Smith Chemical Co., Columbus, Ohio, 1952.
(11) Stillman, J. W., J. Chem. Educ., **27**, 147 (1950).
(12) Elving, P. J., *ibid.*, **27**, 142 (1950).

THE JAPANESE CHEMICAL LITERATURE[1]

LEO J. STEVENS
Smith, Kline & French Laboratories, Philadelphia, Pennsylvania

THE Portuguese and Dutch share the honor of being the first to introduce certain aspects of Western science to Japan; for example, medicine in the sixteenth century.[2] Yoan Udagawa first translated a chemical text imported from Holland, the author of which was a Britisher named Henry.[3] In 1823, Philip Franz von Siebold, a German physician in Dutch employ, arrived in Nagasaki to initiate lectures on clinical medicine.[2] However, science in the occidental tradition did not develop before the Emperor Mutsuhito (better known as Meiji) was restored to power as the actual ruler of Japan (Meiji Restoration, 1868)—an historical event which brought about the abolition of many of the outward vestiges of Japanese feudalism, with the repudiation of the preceding policy of isolation and the introduction of occidental knowledge. Then followed the founding of Tokyo Imperial University in 1877. Its early faculty included R. W. Atkinson and S. Divers of Great Britain as professors of chemistry.

The Tokyo Chemical Society was formed in 1878. Within two years a periodical was inaugurated, later to become known as the *Journal of the Chemical Society of Japan*. In 1921 the Tokyo Chemical Society was reorganized into the Chemical Society of Japan. This learned group has cooperated with the International Atomic Weight Committee since 1899.[3]

With the modernization of Japan, science and scientific literature made rapid progress—a period during which a considerable number of reputable Japanese chemists emerged, among them Nagai, the discoverer of ephedrine (1887). However, the war years 1941–45 proved detrimental to scientific progress in Japan, and with the end of hostilities economic conditions during the occupation often interfered with academic or industrial research. Nonetheless, now considerable scientific activity, particularly in chemistry, is revealed by the growth of professional societies (the Chemical Society of Japan has now more than 12,000 members), the increase in the number of periodicals published, and many other related developments.

PUBLICATIONS OF SCIENTIFIC INSTITUTIONS AND PROFESSIONAL SOCIETIES

Nihon Gakushin is the Japan Academy, formerly known as the Imperial Academy of Japan, inaugurated in 1887. It is now an honorary organization affording membership to those who have made outstanding contributions to science. The Japan Academy is comprised of two sections: Cultural Sciences and Natural Sciences.[4] *The Proceedings of the Japan Academy* are published in English by the Japan Academy in Tokyo.

Nippon Kagakukai, the Chemical Society of Japan, assumed its present name in 1921. As a professional society it publishes several important periodicals. Nippon Kagaku Zasshi is the Pure Chemistry Section of the *Journal of the Chemical Society of Japan*. Publication commenced in 1880 and it appears monthly in Japanese. Kōgyō Kagaku Zasshi, the Industrial Chemistry Section, is a monthly printed in Japanese. The subdivision of the *Journal of the Chemical Society of Japan* into the two sections mentioned occurred in March, 1948.[5] The *Bulletin of the Chemical Society of Japan* is likewise published by this society. A bimonthly, the *Bulletin* appeared first in 1927, and it prints articles in English, German, and French. Another organ of the Chemical Society of Japan is Kagaku To Kōgyō, *Chemistry and Chemical Industry*, printed monthly in Japanese.

The Society of Organic Synthetic Chemistry sponsors Yūki Gōsei Kagaku Kyôkai Shi or *Journal of Organic Synthetic Chemistry*. The journal is a monthly and is printed in Japanese with English titles.[3, 5]

Nippon Butsuri Kagaku Kenkyu Kai, the Physicochemical Society of Japan, was founded in 1925 in connection with the Faculty of Science, Kyoto University, and has at the present more than 700 members.[4] *The Review of Physical Chemistry of Japan* is printed by Marzen & Co., Ltd., Tokyo.[6] Nippon Nōgeikagaku Kaishi or *The Journal of the Agricultural Chemical Society of Japan* is printed monthly in Japanese with English summaries.[3, 5] Kagaku No Ryôiki or *The Journal of Japanese Chemistry* is published by the Nankôdô Publishing Company as a monthly, printed in Japanese. It was introduced in 1922.[3, 6] *Acta Phytochimica* is also published by the same firm for the Societas Phytochimica. It appears irregularly and is printed in English, French, or German.[3, 5]

[1] Presented before the 125th Meeting of the American Chemical Society, Kansas City, March 29, 1954.

[2] "The Encyclopedia Americana Complete in Thirty Volumes," Chicago Americana Corp., New York, 1949–53, pp. 689–92.

[3] FUJISE, SHIN-ICHIRO, Private communication, Sept. 28, 1953.

[4] "The World of Learning," 4th ed., Europa Publications, Ltd., London, 1952, p. 503–22.

[5] "List of Periodicals Abstracted by Chemical Abstracts," American Chemical Society, Columbus, Ohio, 1951, p. cxxi.

[6] SMITH, W. A., F. L. KENT, AND G. B. STRATTON, "World List of Scientific Periodicals Published in the Years 1900–1950," Academic Press, Inc., New York, 1952.

Kagaku Kikai or *Chemical Engineering* is the organ of the Society of Chemical Engineers, appearing bimonthly in Japanese with English abstracts.[3] Tokyo Kogyo Shikenjo Hokoku or *Report of the Government Chemical Industrial Research Institute, Tokyo* is published twice a year in Japanese. *Science Reports of the Research Institutes, The Tôhoku University* (Series A: Physics, Chemistry and Metallurgy) had its inception in 1948 as a bimonthly. It is printed in English.

Nihon Seika Gakkai, the Japanese Biochemical Society, is associated with the Department of Biochemistry, Medical School, Tokyo University. The society publishes Seikagaku, or *Biochemistry*.[3, 5] Nippon Butsuri Gakkai, the Society of Japanese Physicists, dates its origin to 1877. With a roster of over 2000 members, it publishes Nippon Butsuri Gakkai shi, the *Journal of the Society of Physicists*.[4]

The Pharmaceutical Society of Japan is one of the most important professional societies. Since 1880 it has published *The Journal of the Pharmaceutical Society* (Yakugaku Zasshi), and since 1953, the *Pharmaceutical Bulletin*, a quarterly in English, German, or French. Nihon Yakuri Gakkai, the Pharmacological Society of Japan, was instituted in 1881, a few years following the introduction of pharmacology to Japan in 1876.[3] This society resides at the Department of Pharmacology, Medical School, Tokyo University. It publishes Nippon Yakurigaku Zasshi, *The Journal of the Japanese Pharmacological Society*, and Yakurigaku or *Pharmacology*, both appearing monthly in Japanese.[7] The *Folia Pharmacologica Japonica* is published by the Japanese Pharmacological Association at Kyoto University, usually appearing in Japanese with a *Brevaria*, containing abstracts in English or German of the articles printed wholly in Japanese. It appears irregularly.[5] Nihon Seiri Gakkai is the Japanese Physiological Society and it publishes Nihon Seirigaku Zasshi, the *Journal of the Japanese Physiological Society*, in Japanese with short English summaries.[5] The Congress of Japanese Bacteriological Societies (Nihon Saikingakkai), one of the larger professional societies with 2500 members, publishes the *Japanese Journal of Bacteriology*. Kampo To Kanyaku, *Chinese Medicine and Drugs*, is published by the Japanese Society of Chinese Medicine, appears irregularly, and is printed in Japanese.[7]

ABSTRACTS OF THE JAPANESE CHEMICAL AND RELATED LITERATURE

The importance of abstracting Japanese scientific articles, otherwise wholly or partially inaccessible because of the linguistic barrier, was recognized early by the German *Chemische Zentralblatt*, the American *Chemical Abstracts*, the *Journal of the Chemical Society* (*London*) (abstracts 1871–1925), and the *British Chemical Abstracts*. Over the period of time following their first appearance in 1907, *Chemical Abstracts* has given increasing attention to Japanese chemical literature. This is described by the editor of *Chemical Abstracts*, E. J. Crane, in two articles[8, 9] from which the following statistics are taken:

Abstracts of Japanese articles published in *Chemical Abstracts* were 0.3 per cent of the total in 1909, and 9.1 per cent in 1951 (first half of the year); however, the Japanese chemical literature was not covered completely before 1918. In comparison, American articles were 20.1 per cent in 1909 and 36.6 per cent in 1951; German articles made up a large part of the total in 1909 (45.0 per cent), while they represented only 7.9 per cent in 1951.[9]

For a number of years World War II prevented the growth of the coverage of Japanese chemical literature. After the war, Editor Crane re-established connections with Japanese literature[10] and by 1948 *Chemical Abstracts* had again received abstracts of approximately 5000 articles that had appeared in Japan since 1941.[11]

Boig and Howerton made a statistical analysis of articles abstracted from chemical periodicals in the field of organic chemistry (1877–1949). They show that 88 Japanese articles were abstracted by *Chemical Abstracts* in 1949, to account for the sixth place—English, German, Russian, French, and Italian organic articles leading in that order.[12] Similar statistics for analytical periodicals (1877–1950) reveal 48 Japanese articles abstracted by *Chemical Abstracts* in 1950, again placing the Japanese language sixth after English, Russian, French, German, and Spanish.[13]

The need for abstracting facilities was recognized by a group of Japanese chemists around Riko Majima, formerly Professor of Chemistry at Tôhoku University, now a member of the Japan Academy. He began in cooperation with Junjiro Kushibiki and others, to classify, abstract, and index Japanese chemical literature. In 1926 Nihon Kagaku Kenkiukai, the Japanese Chemical Abstracting Society, was founded. Seven volumes were published from 1927 to 1938, covering Japanese chemical literature from 1877 to 1926; more than 23,000 abstracts and a great number of patents (21,662) were published. Monthly issues appeared from January, 1927, to July, 1945, when the editorial office and the library were destroyed in air raids. Following World War II financial conditions made the publication very difficult and in that period only incomplete abstracts were published. Financial subsidies by the Japanese Ministry of Education and many chemical firms permitted the resumption of monthly abstracts from 1951 on, and an annual index appeared. At the present, the abstracting service is functioning normally. In 1951, 3503 abstracts and 1252 patents were published; in 1952, 4255 abstracts and 1697 patents; and up to July, 1953, 2535 abstracts and 1443 patents were published. In 1952, 736 publications

[7] SUGASAWA, S., Private communication, July 11, 1953.

[8] CRANE, E. J., *Chem. Eng. News*, **26**, 3342–43 (1948).

[9] CRANE, E. J., *ibid.*, **29**, 4250–3 (1951).

[10] ANON., *ibid.*, **25**, 1028 (1947).

[11] ANON., *ibid.*, **26**, 1136 (1948).

[12] BOIG, F. S., AND P. W. HOWERTON, *Science*, **115**, 25–31 (1952).

[13] BOIG, F. S., AND P. W. HOWERTON, *ibid.*, **115**, 555–60 (1952).

were abstracted; of these 113 were written in English, French, or German. This would indicate that Nihon Kagaku Soran, the *Japanese Chemical Abstracts*, is progressing satisfactorily.[3]

Since 1941 Seitetu Gizyutu Soran, the *Metallurgical Abstracts*, has been published monthly in Japanese by the Engineering Department of the Yawata Iron and Steel Company. Some chemical articles are abstracted.[14] Nippon Kôgyô Soran, the *Japanese Engineering Abstracts*, are published by the Kôsyunkaku Publishing Company and edited by Nippon Kôgakukai, the Engineering Society of Japan. Printed in Japanese, they have appeared since 1949.[14] Gakuzyutu Bunken Hukyûkai is an abstracting service which brings out abstracts of scientific and technical literature in the form of printed cards. Interrupted during the war, it was resumed in 1950; the abstracts are in Japanese.[14] The oldest Japanese abstract journal is Igaku Tyûô Zasshi, the *Central Review of Medicine*, with an abstract service inaugurated in 1903 by Siro Amako. The *Review* appears bimonthly, covers more than 270 medical, pharmacological, and related journals, and is printed in Japanese.[14]

No treatises of chemistry of the type of *Beilstein* or *Grignard* exist in the Japanese language.[15]

MEDICAL PUBLICATIONS

The present favorable development of clinical research in Japan is reflected by the great number of clinical journals and papers printed. Practically all specialized fields of medicine are represented in Japan by learned societies and pertinent publications. Several are of interest to chemists concerned with problems of medicinal or pharmaceutical chemistry.

Acta Scholae Medicinalis Universitatis in Kioto prints in English or German papers originating from the Medical and Pharmaceutical Departments of Kyoto University. The journal is distributed without charge to suitable institutions or scientists. The *Tôhoku Journal of Experimental Medicine*, incorporating *Arbeiten aus dem anatomischen Institut der Kaiserlich-Japanischen Universität zu Sendai*, and *Mitteilungen über allgemeine Pathologie und pathologische Anatomie*, is printed in English, French, and German and is one of the oldest in Japan. Publication began in 1877; U. S. representative is Chas. E. Tuttle Co., Rutland, Vermont. Papers on experimental medicine, pathology, and other related subjects are very frequent. *Japanese Journal of Experimental Medicine* has been published semiannually since 1930 by the Institute of Infectious Diseases, Tokyo University. Articles appear in English. Nippon Saikingaku Zasshi or the *Japanese Journal of Bacteriology* is printed monthly, in Japanese. *The Japanese Medical Journal*, published by the National Institute of Health of Japan, appears in English, bimonthly; it is concerned with medical progress and public health. *Japanese Journal of Medical Science and Biology* is also published by the National Institute of Health. Quarterly since 1947, it is printed in English, featuring papers on immunology, biology, virology, etc.

Keio Journal of Medicine is published quarterly by Keio University and dates from 1952; all articles are in English. *Yokohama Medical Bulletin*, founded by I. Takaki, is a bimonthly publication of Yokohama University, in English. Kyoto Furitsu Ikadaigaku Zasshi (*Journal of the Kyoto Prefecture College of Medicine*) is distributed monthly in Japanese with English or German summaries; occasionally articles are printed in English or German with Japanese summaries.

The *Pharmacopoeia Japonica* must also be mentioned. It is written in Japanese with titles in Latin and English, makes reference to the *U. S.* and *British Pharmacopoeias*, the *National Formulary*, and *New and Non-official Remedies;* there is an edition in English.

DICTIONARIES AND PATENTS

Although there are Japanese and Japanese-English dictionaries, only a few specialize in chemical or related terminology. Rikagaku Jiten ("Dictionary of Physics and Chemistry"), edited by Professor Jun Ishihara and published by the Iwanami Book Co., Tokyo, is a Japanese-English (and French and German) dictionary.[15, 16] Rikagaku Jiten Zohokaitei Han or "Japanese Dictionary of Physics and Chemistry" by Ishihara and co-workers has an American edition (G. Wahr, Ann Arbor, Michigan, 1942, 1966 pages).[17] There is a specialized medical dictionary entitled "Medical Dictionary," published by Nanzando in Tokyo, 1953.[15]

Chemical terminology may be found in ordinary dictionaries; for example, in Sir Satow and Masakata Ishibashi's "An English-Japanese Dictionary of the Spoken Language, American Edition." This book was published by P. D. and Ione Perkins, South Pasadena, California, in 1942, and is now somewhat out of date. The Japanese equivalents of the English words are written in romanized form.[18] Fujita's "Kenkyusha English-Japanese Dictionary, Commercial and Technical Terms," also published by P.D. and Ione Perkins, 1944, 1220 pages, contains some chemical terms and a list of English abbreviations with Japanese equivalents.

A Webster-type dictionary published in our country is Okakura's "Kenkyusha's New English-Japanese Dictionary on Bilingual Principles," University of California Press (Berkeley, 1945), 2514 pages.[18] Representative of other purely Japanese dictionaries is one by Otome Daniels, "Dictionary of Japanese (Sôsho) Writing Forms" (London, Lund Humphries, 1944).[18] There is also the Dai-Jiten ("Great Dic-

[14] Isiwara, Hirosi, *Rev. Document. The Hague*, **20**, 27–30 (1953); see also *Chem. Lit.*, **5**, 11 (1953).

[15] Sugasawa, S., Private communication, Nov. 19, 1953.

[16] Yoshioka, J. G., Private communication, Nov. 18, 1953.

[17] The Philadelphia Bibliographical Center and Union Library Catalogue, Private communication, Nov. 12, 1953.

[18] Winchell, C. M., "Guide to Reference Books," Am. Library Association, Chicago, 1951, pp. 241–42.

tionary"), compiled by Heibonsha, Tokyo, 1934–36, in 26 volumes, which is the Japanese equivalent of a dictionary of the unabridged Webster or Oxford-type.[18] Fumihiko Otsuki's Dai-Genkai, published in Tokyo 1932–35, consists of four volumes and index. This dictionary includes the etymology of words, a rare practice among Japanese lexicographers.

Only little can be said about Japanese patents as a source of information for the chemist searching the literature; however, Japanese patents are being abstracted by *Chemical Abstracts*. Information about them may also be had by consulting Tokkyo Koho, the official patent report appearing irregularly in Japanese, published by Hatsumei Kyokai, The Patent Office, Tokyo.[5,19]

ACKNOWLEDGMENTS

This paper was written in collaboration with Shinichiro Fujise, Tôhoku University, Sendai, Japan.

Appreciation is extended to Dr. Shigehiko Sugasawa, Department of Pharmacy, Tokyo University (retired), for his advice and contribution of valuable information.

[19] CALVERT, R., "Patent Practice & Management for Inventors and Executives," Scarsdale Press, Scarsdale, New York, 1950, p. 328.

NUCLEAR CHEMISTRY AT HARVARD

GEOFFREY WILKINSON, RICHARD M. DIAMOND, and EUGENE G. ROCHOW
Harvard University, Cambridge, Massachusetts

HARVARD'S first cyclotron went to war early. As recorded in the Smythe report, that cyclotron was transplanted to Los Alamos in 1943. In the immediate postwar years a new and larger cyclotron, with better instrumentation and control, was constructed in a new nuclear laboratory adjacent to the departments of chemistry and physics. For six years this new instrument has been in active use on the problems of nuclear physics.

Within the same postwar years nuclear chemistry has undergone a particularly rapid development as a broad field of scientific endeavor, not only directly in the study of nuclear phenomena but indirectly in the further use of radioactive tracers in the solution of chemical problems. With this development has come the recognition of nuclear chemistry as an individual discipline in courses of instruction. Nuclear and radiochemical research and teaching in other institutions has been discussed before in THIS JOURNAL;[1] in this note we should like to point out the potential of the chemistry department at Harvard University for research in nuclear chemistry for students who wish to do work in the field for the Ph.D. degree.

During the past three years a laboratory for nuclear and radiochemical studies has been set up in the Department of Chemistry, and a program of research has been started in which the Harvard synchrocyclotron and a variety of radioactive tracers are being applied to problems in inorganic and physical chemistry. The laboratory facilities at hand include equipment for Geiger, proportional, and scintillation counting, in addition to customary radiochemical protection and monitoring equipment, and present an excellent basis for a wide range of research interests. The Harvard 95-inch synchrocyclotron is available for use in bombardment and radiochemical studies. It has a unique feature that makes the cyclotron of unusual utility from the chemist's point of view. This feature is a tantalum scattering device by means of which the circulating proton beam can be deflected back into the magnetic field of the cyclotron. These deflected protons are focused by the field in positions dependent upon their energy, and in consequence beams of protons of accurately known energy range are available. Thus protons from 15 to 100 m. e. v. can be obtained where, for small targets, the energy resolution is better than 0.5 m. e. v.; this contrasts strikingly with most other cyclotrons, in which beams are usually obtained with a several-m. e. v. spread in energy. The Harvard cyclotron is hence a unique instrument for precise studies on the yields of nuclear reactions as a function of proton energy. Such studies of excitation func-

[1] Symposium on Teaching Nuclear Chemistry, J. CHEM. EDUC., 28, 2–14 (1951): R. T. OVERMAN, H. M. CLARK, W. M. HAMILL, R. R. WILLIAMS, JR., R. H. SCHULA, I. PERLMAN, G. T. SEABORG, C. D. CORYELL, AND J. W. IRVINE, JR.

tion are of great importance in providing data for a better understanding of the mechanisms of nuclear reactions and of the range of validity of proposed models (such as the formation of compound nuclei at low bombarding energies and the knock-on process at high energies). Another advantage of the Harvard cyclotron in this type of work is that its energy range (up to 110 m. e. v.) bridges the gap between ordinary cyclotrons (<20-m. e. v. protons) and the few large (400-m. e. v.) synchrocyclotrons that have been built. It is just in this region of energies that the knock-on process becomes of importance and competes with the formation of a compound nucleus according to the earlier Bohr concept.

Excitation functions for proton reactions in several elements have already been carried out by Dr. J. W. Meadows at the Harvard Nuclear Laboratory, and work of this type is being extended in this department. Cobalt has been bombarded at various energies, and the yields from reactions involving only a few nucleons (for example, (p, pn), $(p, 3n)$ etc.) have been studied as a function of the energy of the bombarding protons. The yields of reactions involving a larger number of particles (spallation reactions) are now under investigation. These studies have required considerable subsidiary chemical research on the preparation of thin cobalt targets, and on the chemical separation of nickel, iron, manganese, and vanadium from the target material.

When target elements of high atomic number are used, spallation reactions merge into fission, and again the energy range of the Harvard cyclotron makes it most useful for studying the changeover from low-energy asymmetric fission to high-energy induced symmetric fission. The variation with energy of the fine structure in the asymmetric fission peaks may be studied and these data are very necessary for the development of any satisfactory theory of fission.

Studies have also been made on new radioactive isotopes of molybdenum, niobium, and titanium. Since no long-lived isotope of titanium had previously been known, the new Ti^{44} species of approximately three years half-life is potentially of great interest for tracer studies in the chemistry and metallurgy of titanium.

Several chemical problems involving the use of radioactive tracers are now in progress. A study of the behavior of metal ions in strongly acid solutions in ion exchange columns is one example. This is yielding information on the state of hydration of cations in solutions of high ionic strength, as well as on the ion exchange process itself. The problem of extractability of molybdenum from hydrochloric acid solutions into ether and related solvents, a process known for many years but never systematically investigated, is being re-examined using a radioactive tracer, the object being to obtain information on the mechanism of extraction and the species involved.

On the teaching side, a course in nuclear chemistry (Chemistry 165), open to seniors and graduate students, now is being given. The lecture material is in part similar to that described by Coryell and Irvine.[2] Students are introduced to radiochemical techniques in laboratory work given as a separate part of the course; this work involves the use and calibration of counters, the measurements of radiation character of β and γ rays by absorption methods, and radiochemical separation of increasing complexity. Seniors may also take an undergraduate research course (Chemistry 96) and first-year graduate students a laboratory training and research course (Chemistry 156) in nuclear or radiochemical work. For the doctorate degree in this field the requirements are the same as those for other fields of chemistry in this department: the incoming graduate student is required during his first year to pass qualifying examinations in inorganic, organic, physical, and analytical chemistry, to demonstrate ability to read articles in two foreign languages (French, German, or Russian) and to pass at least one advanced course in each of the major fields of chemistry. As soon as he has completed his qualifying examinations and the course requirement the student may begin experimental work leading to a thesis. Students taking nuclear chemistry for the Ph.D. degree need not have had any previous acquaintance with nuclear work.

In addition to the facilities for nuclear chemistry at Harvard, the Cambridge-Boston area offers further opportunity for informal training at the other institutions where research in similar fields is highly developed. Joint seminars are held with the chemistry department at the Massachusetts Institute of Technology in both physical and nuclear chemistry. Furthermore, the excellent facilities of the Brookhaven National Laboratory are available for special problems.

One may ask why a new program in nuclear chemistry research has been set up at Harvard in the face of well established and well supported operations on a much larger scale elsewhere. We feel that quite apart from the unique opportunities afforded by the new cyclotron, which we have described in some detail above, there always are many more new ideas than can be investigated in existing establishments. The relative freedom of action in a smaller institution has its own appeal, provided the institution has facilities adequate to the idea being investigated. We feel that the real importance of nuclear studies is only just beginning, and that the potential for interesting and profitable work at the graduate level is high at Harvard.

[2] *Ibid.*, **28**, 14 (1951).

A SUBLIMATION APPARATUS FOR RAPID SEPARATIONS

LEWIS N. PINO and WINFIELD S. ZEHRUNG III
Allegheny College, Meadville, Pennsylvania

STEAM distillation or fractional crystallization is commonly used to separate mixtures of ortho-para isomers. If the ortho isomer is chelated, steam distillation is the usual means of separation. However, steam distillation in the laboratory is a lengthy process if large quantities of a pure isomer are desired.

If the isomers involved have reasonable thermal stability, separation by sublimation should work well. If higher temperatures than those obtained in steam distillation can be used without damage to the nonvolatile isomer, much more rapid separation should result. Experiments with 20 to 60-g. mixtures of 2-amino-3-nitropyridine and 2-amino-5-nitropyridine showed that rapid, nearly quantitative separations could be made using temperatures around 120°C.

We used in this work our own macrosublimation apparatus which was designed to allow accurate temperature control and ease of recovery of the residue. Most sublimators (*1–7*) were designed with purification of the sublimate in mind rather than preservation of the nonvolatile material.

The apparatus shown in the figure is easy to construct and to use. Changes in scale would allow its use on micro or semimicro samples. In preparing the apparatus for use, a Pyrex wool plug *F* is placed in one end of the sublimation chamber and the chamber filled with the dry mixture. The drying tube is inserted into the end of the sublimation chamber. This assembly is then placed in the air jacket into which the condenser has already been fitted and sealed with two turns of asbestos cloth *E*.

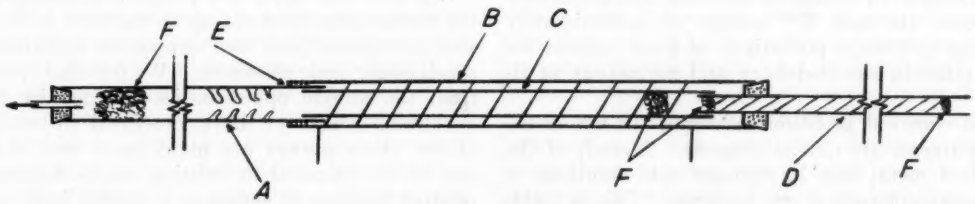
An aspirator is connected to the condenser to provide an air current to transport the vapors of the sublimate. The sublimation area is gradually brought to the correct temperature by the heating coil. A variable autotransformer is used to control the power supplied to the heating coil and thus control the temperature. A thermometer may be placed in the sublimation chamber for calibration runs. If the proper temperature is used, little or no decomposition of the nonvolatile isomer results. For easily oxidizable materials a dry nitrogen atmosphere could be used.

Upon completion of the separation the residual material may be shaken into a beaker for recrystallization. The sublimate may be extracted from the condenser and recrystallized in one step with an appropriate solvent.

We have reported this apparatus in the hope that others may find it useful as a device for separating isomeric mixtures now separable only by steam distillation or fractional crystallization.

LITERATURE CITED

(1) CAROTHERS, W. H., AND J. W. HILL, *J. Am. Chem. Soc.*, **54**, 1557 (1932).
(2) MOREY, G. W., *ibid.*, **34**, 550–2 (1912).
(3) PITHA, J., J. CHEM. EDUC., **23**, 403 (1946).
(4) HELIN, A. F., AND C. A. VANDER WERF, *Anal. Chem.*, **21**, 1284–5 (1949).
(5) MORTON, A. A., J. F. MAHONEY, AND G. RICHARDSON, *ibid.*, **11**, 460–1 (1939).
(6) NELSON, O. A., *ibid.*, **14**, 153 (1942).
(7) ROBINSON, G. R., AND T. W. DEAKERS, J. CHEM. EDUC., **9**, 1717 (1932).



Sublimation Apparatus

A. Condenser tube: 72.5 cm. × 3.2 cm. *B.* Heater tube: 61 cm. × 4.2 cm. wound with 25 ft. of No. 22 Chromel wire. *C.* Sublimation chamber: 52 cm. × 2.6 cm. *D.* Drying tube with indicating drierite: 58 cm. × 2 cm. *E.* Asbestos cloth, 1 in. wide. *F.* Pyrex wool.

A MAGNETIC MODEL OF POLYELECTROLYTE INTERACTION

B. E. CONWAY
The Chester Beatty Research Institute,
London, England

A NUMBER of properties of polyelectrolytes and their solutions must be envisaged as arising from electrostatic interactions of various kinds; thus intramolecular and intermolecular interactions, as well as interactions between the polymeric ions and their counter-ions, are possible. The degree of over-all extension of flexible polyelectrolytes, and hence their viscosity, has been ascribed (*1*) to the mutual effects of the ionized groups on the polymer; and various osmotic, conductance, viscosity, and titration effects have been ascribed to interactions occurring between the polyion and its counter-ions (*2–5*). These interactions are all determined fundamentally by a force law (operating between charges e and e') of the form:

$$F = \frac{e \cdot e'}{Dr^2}$$

where F is the force between the charged groups at a distance r, in the solution of dielectric constant D. An exactly similar law holds for magnetic interactions, so it should be possible to construct a magnetic model that represents the electrostatic situation in polyelectrolyte solutions by means of magnets floating on water with their axes supported vertically in corks.

As magnets are necessarily dipolar, isolated poles which would exactly simulate electric charges cannot readily be obtained without complicated screening arrangements. However, if the magnets are all aligned with their like poles above the water and if the distance between them is small compared with their length, the diagonal heteropolar interactions (attractions) are relatively small. Thus for magnets 10 cm. long and 2 cm. apart the repulsive forces between the like ends are about 25 times greater than the diagonal attractive forces, and the model approximates a system of isolated like poles or like charges.

Models of polyelectrolyte molecules may be constructed by floating a number of magnets in small corks as in Figure 1 and joining them together at a small distance of separation by means of thread (for flexible polyelectrolytes), very fine wire (semiflexible polyelectrolytes), or stiffer wire for rigid polyelectrolytes. A string of 15 to 20 magnets in corks is sufficient to demonstrate the general principles of polyelectrolyte behavior. Counter-ions may be represented by isolated floating magnets of opposite polarity.

Owing to the nature of the medium and to the lack of any effective Brownian motion, magnets of opposite sign are attracted close to one another immediately.

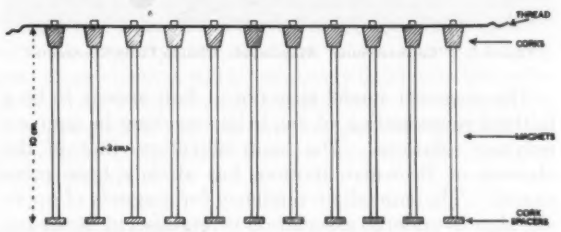


Figure 1. Diagram of Arrangement of Magnets in Corks

If a flexible line of magnets of the same orientation representing a fully charged particle is put in the water bath it assumes an approximately linear configuration, Figure 2. Upon insertion of "counter-ions," the "charges" become neutralized and the model folds up into a compact, approximately circular mass (Figure 3). Removal of the "counter-ion" magnets one by one causes a reversal of the process and the coil again expands. In the contracted condition the model is the analogue

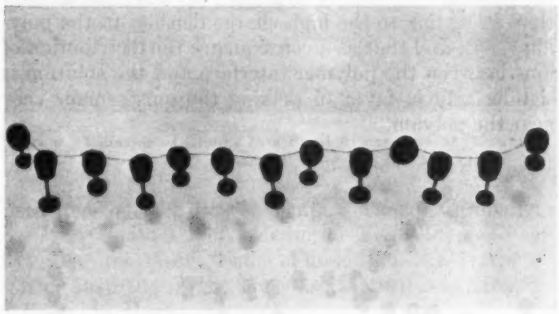


Figure 2. Chain Fully Extended by Repulsion; "Counter-ions" Fully Dissociated

of the uncharged parent polymer or perhaps more exactly of the polyelectrolyte in excess of neutral salt. In observing the model it is of interest to note that the counter-ion charges not only diminish the repulsive interaction down the chain, but may also give rise to *local attractions* between two or three adjacent polymeric charge units on a given chain, pulling these centers nearer together than they might otherwise be. This is exactly the behavior that is observed in viscosity experiments (*14, 15*) where the polymer salt is found to have a much smaller effective volume in the presence of excess neutral salt than has the parent uncharged polymer acid or polymer base.

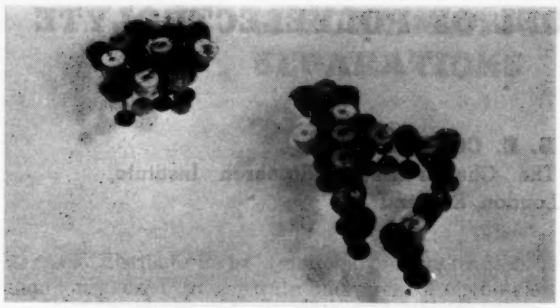


Figure 3. "Counter-ions" Associated; Chains Fully Contracted

The magnetic model may not at first appear to be a faithful reproduction of conditions existing in aqueous polymer solutions. The main objection, that of the absence of Brownian motion, has already been mentioned. The immediate tendency for magnets of opposite sign to undergo association is reminiscent of the behavior of strong electrolytes in media of low dielectric constant, and this model for *aqueous* solutions would at first sight appear to be misleading. However, it has been demonstrated both experimentally in conductance and osmotic studies (*3, 4, 5*) and theoretically in calculations (*6*), that considerable counter-ion association with the polymeric ion occurs. This arises not on account of the low dielectric constant of the medium—for in the dilute solutions used experimentally it can be little below the static value of 78 for water—but from the fact that the electrostatic potential energy of ions near the polyion is unusually large, *i.e.*, several times greater than kT owing to the high charge density on the polyion (*7, 8*), and that as a consequence the distribution of ions between the polymer interface and the solution is significantly in favor of making the ions remain very near the polyion.

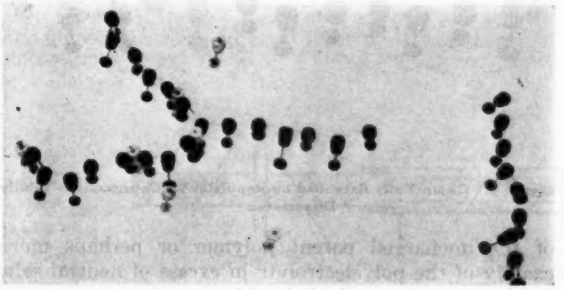


Figure 4. Local Association of Two Chains Through a Shared "Counter-ion"

The magnetic model therefore simulates the conditions in polyelectrolyte solutions more accurately than might at first have been supposed. It will be of interest to consider other properties in the light of the behavior of the model.

From the dependence of the reduced specific viscosity on concentration of a polyelectrolyte (*10*) and the effects of salts and shear on this dependence, Conway and Butler (*9, 11*) suggested that for desoxyribonucleic acid the abnormally high viscosities of polyelectrolyte solutions of finite concentrations compared with their *intrinsic* viscosities—and also the marked shear dependence in these more concentrated solutions—could be explained by postulating that local ionic interaction occurs in the salt-free polyelectrolyte solution (*cf. 18*). The reason for this effect is the tendency for counter-ions to attempt to complete their "Debye-Hückel" ionic atmospheres by locally utilizing segments of the polymeric anions, no other simple ions of opposite charge being available. This would give rise to a spectrum of local interactions varying in strength throughout the polymer solution, and could explain its weak gel-like behavior.

Examination of the behavior of the model readily demonstrates that this kind of interaction is possible. If a highly charged pair of model polymer particles is taken, introduction of one or two counter-ions is enough to cause *local attraction* where segments of the polymeric ions and a counter-ion happen to be sufficiently near to one another. The bulk of the polymeric ions are still repelled from one another but the beginnings of a network formation are easily discerned (Figure 4). The local interactions are weak and are the result of a balance of local short-range attractive forces between one counter-ion and several charges on the polymeric anions that are nearby, and more general repulsive forces between the remainder of the polymer charges at greater distances. Locally, the attractive forces are seen to be greater than the repulsive forces. Thus, for example, if two counter-ions of charge e are at distances in a straight line of r_1 and r_2 from unshielded polymer segments of charge e in two chains, the repulsive force between these two segments would be

$$\frac{e^2}{D(r_1 + r_2)^2}$$

if the counter ions were not present. Owing to their presence, however, these give rise to an attractive force on the polymer segments in an opposite direction of

$$\frac{e^2}{D}\left(\frac{1}{r_1^2} + \frac{1}{r_2^2}\right)$$

per ion.

For any real positive values of r_1 and r_2 the attractive forces because of the counter-ions are greater than repulsive forces between the segments. The net attractive force demonstrated by the model is precisely similar to the Debye-Hückel attractive force causing ionic interaction in solutions of simple strong electrolytes, and to the attractive forces in ionic crystals. By introducing counter-ions of greater valence, *i.e.*, two or three magnets together, much stronger attractive forces are observed (Figure 5) and the behavior is the analogue of gelation, which can be induced experimentally in polyacrylate solutions by Ca or Ba ions (*16*). It is clear that the strong interaction brought about by the divalent counter-ions in this case must also occur to a diminished but significant extent when

the divalent ions are replaced by their equivalent of monovalent ions. Such effects have been discussed by Butler and Conway (*11*) and Conway and Butler (*9*).

By applying a small shearing force to the model in which interpolymer interactions of this kind exist, it

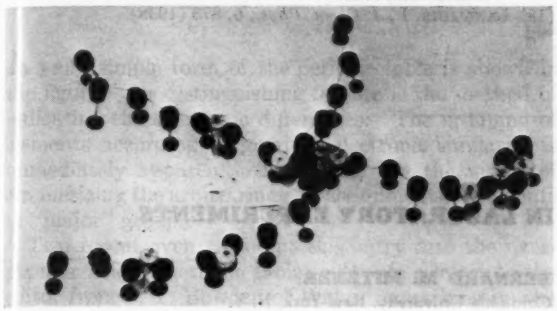


Figure 5. Stronger Local Association of Three Chains Through a Shared Polyvalent "Counter-ion"

can be demonstrated that movement of one polymer-model particle can be conveyed to the other interacting model through the magnetic linkage, provided the speed of motion is not too large. At higher speeds of motion the local interaction is ruptured. The marked dependence of viscosity of nucleic acid on shear at all but the highest dilutions suggests that this kind of process is in fact occurring (*12*) and that the high shear-dependence at very low rates of shear arises from local electrostatic interactions that are progressively broken with increasing rates of shear. In addition to the local rupture of interchain interactions by the shearing force, the chains are forced into a configuration in which they are parallel. When this occurs, local attractive interactions are outbalanced by a general repulsion between the similarly charged parallel chains. For comparison, the experimental concentration-dependence of reduced viscosity of polyelectrolytes at high rates of shear is much diminished, compared with the behavior at low or zero shear, and the effect of neutral salts is less. This suggests that interpolymer interactions are diminished by the shear, as is demonstrated by the model. In a real solution of a polyelectrolyte the polymer chain necessarily finds itself in an atmosphere of counter-ions at various distances from the charged chain, the total charge in this atmosphere being equal and opposite to that on the polymer chain. Owing to the lack of Brownian motion in the model, this situation is difficult to achieve with the magnets. However, the behavior of the magnetic model in an atmosphere of counter-ions, qualitatively approximating that existing in real solutions, may be studied by placing the chain of magnets among magnets of opposite polarity fixed at various positions in the bath (Figure 6). Under these conditions the local effect of any given counter-ion in effecting association between two chains of the type shown in Figures 4 and 5 is diminished, owing to the simultaneous attractive effects of neighboring counter-ions in an opposite direction on the elements of the chains. The net attractive effect between similar chain elements depends on the diameter of the magnet "counter-ions" and is naturally greater the smaller the diameter of the associating "counter-ion," or the greater its valence. In real solutions the local associating effect of counter-ions might be expected to be dependent on their ionic radii or, probably more correctly, upon their Stokes radii (*13*).

The weakness of the model is mainly that no Brownian motion is occurring (though this can be simulated by stirring the water in which the models are floated); the general behavior observed must occur to a greater or lesser extent in real solutions where a proportion of ions at any instant will be relatively fixed near the polymeric ions. Experiment suggests that this proportion is not negligible and the interactions demonstrated by inspection of the model may be expected also to occur in real solutions.

ACKNOWLEDGMENT

This investigation has been supported by grants to the Royal Cancer Hospital and Chester Beatty Research

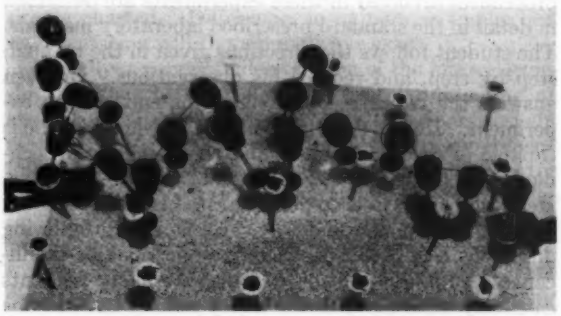


Figure 6. Behavior of Chains in a Fixed Atmosphere of "Counter-ions"

Institute from the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund, and the National Cancer Institute of the National Institutes of Health, U. S. Public Health Service.

LITERATURE CITED

(1) Arnold, R., and J. Th. G. Overbeek, *Rec. trav. chim.*, **69**, 192 (1950).
(2) Huizenga, J. R., P. F. Grieger, and F. T. Wall, *J. Am. Chem. Soc.* **72**, 2636 (1950).
(3) Wall, F. T., G. S. Stent, and J. J. Ondrejcin, *J. Phys. & Colloid Chem.*, **54**, 979 (1950).
(4) Kern, W., *Z. physik. Chem.*, **A181**, 249 (1938).
(5) Strauss, U. P., and R. M. Fuoss, *J. Polymer Sci.*, **4**, 457 (1949).
(6) Fuoss, R. M., A. Katchalsky, and S. Lifson, *Proc. Nat. Acad. Sci. U. S.*, **37**, 579 (1951).
(7) Katchalsky, A., *Endeavour*, **12**, 90 (1953).
(8) Katchalsky, A., "Proceedings of the symposium on macromolecules, Uppsala, 1953," *J. Polymer Sci.*, in press.
(9) Conway, B. E., and J. A. V. Butler, *J. Polymer Sci.*, in press.

(10) POUYET, J., *J. chim. phys.*, **48**, 90 (1951).
(11) BUTLER, J. A. V., AND B. E. CONWAY, *Nature*, **172**, 153 (1953).
(12) CONWAY, B. E., AND J. A. V. BUTLER, *J. Polymer Sci.*, **11**, 277 (1953).
(13) ULICH, H., A. EUCKEN, and K. L. WOLF, *Hand- und Jahrbuch der chem. Phys.*, Leipzig, **6**, 120 (1933).
(14) FUOSS, R. M., *Discussions Faraday Soc.*, **11**, 125 (1951).
(15) DOTY, P., AND G. EHRLICH, *Ann. Rev. Phys. Chem.*, **3**, 81 (1952).
(16) WALL, F. T., AND J. W. DRENNAN, *J. Polymer Sci.*, **7**, 83 (1951).
(17) VERWEY, E. J. W., AND J. TH. G. OVERBEEK, "Theory of the Stability of Lyophobic Colloids," Elsevier Publ. Co., Amsterdam, 1948.
(18) LANGMUIR, I., *J. Chem. Phys.*, **6**, 873 (1938).

STIMULATING INTEREST IN LABORATORY EXPERIMENTS

BERNARD M. MITZNER
Columbia University, New York, N. Y.

STUDENTS of both inorganic and organic elementary chemistry are presented with a series of experiments which they have to perform in the laboratory. The procedures involved in these experiments are described in detail in the standard prescribed laboratory manuals. The student follows the directions given in the manual, step by step, and records his observations. He then answers the required questions at the end of each experiment. He has done little more than show that he is capable of reading English, and that he has the technique which a high-school freshman is expected to have. He at no time is able to demonstrate his understanding of what he is doing, and why. He is merely following directions, and obtaining results of questionable significance. It is no wonder that a great many students gain very little out of a laboratory session and in some cases even resort to copying other people's data.

This entire system lacks one very essential factor, the student's doing some original thinking of his own. Naturally this does not imply that the standard laboratory manuals are written for morons, but I am sure that a person of this classification can get results equal to those of an intelligent student merely by following the specified directions. A method should be introduced that would cause students to develop a more active interest in what they are doing, and this can be easily accomplished by the following means:

The laboratory experiment is carried out exactly as described in the standard laboratory manual, but an additional question is always added at the end of each experiment. The question is, "Offer valid criticisms on the way in which this experiment has been outlined and offer suggestions that would make it a more satisfactory experiment." This may infuriate at once many authors of laboratory manuals who believe that their procedures are beyond reproach, but there is an ulterior motive involved. If a student knows ahead of time that he will be expected to give a critical evaluation of what he is doing, he will at once be more interested in it. He will also realize that in order to be capable of criticizing something he should attempt to learn as much about it as possible. Thus, while performing the experiment, he will always keep in mind the fact that he will be asked for suggestions on how to improve it.

Most students in both freshman and organic chemistry do not realize that other laboratory manuals, besides the one assigned, are available in the library. Textbooks can also be included in this classification. The more serious student will then spend some time in the library and try to learn how the same experiment is described by other authors. He will therefore have a broader view on that particular experiment as well as on chemistry as a whole.

If this critical method is adopted, not only will the students benefit by their increased interest in the subject matter, but the authors of the standard laboratory manuals may find it rewarding to learn what the students think of their recommended procedures. The students are by no means experts on the subject of experimentation and their criticisms may be meaningless in most cases. However, by this device they are sure to have given some thought to the particular experiment in question, in order to be capable of making worthwhile comments. There are most certainly a great many experiments which are virtually perfect in procedure, and to offer criticisms of these would be folly. Nevertheless, if a student makes even an awkward attempt, we have accomplished our purpose.

ONE MORE PERIODIC TABLE

R. T. SANDERSON
State University of Iowa, Iowa City, Iowa

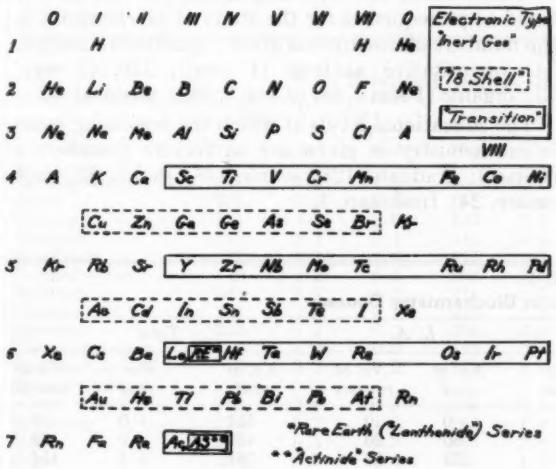
A VERY simple form of the periodic table is shown in the figure. Its distinguishing feature is the method of indicating the electronic differences. The grouping of elements according to greatest electronic similarity is immediately apparent. This table has the virtue of emphasizing the arbitrariness in assignment of elements to "major" groups.

Two recent events prompt this entry into the overpopular field of periodic tables. One is a letter to the editor from S. T. Bowden of Wales,[1] remarking on the present state of confusion in this field and proposing that for teaching purposes the periodic table be standardized by an international committee. The other is the advertisement[2] of a new periodic chart for classroom use, in which Sc, Y, and La are grouped with B and Al as III-A elements, instead of being grouped by themselves as III-B elements as, for example, in the excellent chart prepared from that of H. G. Deming and distributed widely by Merck and Co.

The second event certainly illustrates Professor Bowden's point. Students may readily be bewildered by the apparently fundamental lack of agreement among various periodic tables, and some may even acquire reasonable doubt as to whether chemists actually know what they are doing. I cannot, however, share Professor Bowden's confidence, or hope, that universal agreement could be legislated by an international committee. Periodicity is fundamental, but any periodic table is only an artificial and necessarily somewhat arbitrary effort to align 100 unique, *individual* elements in the most logical possible order for conveniently comparing their properties. The complete complexities of periodicity, in my opinion, can never be simply charted. Differences in opinion as to the best representation will therefore always exist.

Actually, a proper understanding of the interrelationships of the chemical elements may be aided by an awareness of the existence of alternative periodic tables and by an understanding of their differences. For those who prefer, however, to try to minimize the possibilities of confusion, a chart like the figure, which (*a*) indicates clearly the major electronic differences among the elements, and (*b*) groups them solely according to valence, has certain advantages. The grouping of elements according to greatest electronic similarity is immediately apparent. Students can see that complete justification does not exist for grouping either Sc, Y, and La or Ga, In, and Tl with B and Al. The instructor should explain the differences in the various pairs of subgroups, and why or in what ways one or the other subgroup more closely resembles the first two elements of the valence group. The periodic table itself, however, is properly noncommittal.

[1] BOWDEN, S. T., J. CHEM. EDUC., **30**, 426 (1953).
[2] *Ibid.*, **30**, 33(A) (Sept., 1953).



[3] DEMING, H. G., "Fundamental Chemistry," 2nd ed., John Wiley & Sons, Inc., New York, 1947.

SURVEY OF COURSES IN BIOCHEMISTRY

A Committee Report

GORDON H. PRITHAM
Pennsylvania State University,
State College, Pennsylvania

In 1944 a survey of courses in biochemistry was made as the basis for the addition of tests in biological chemistry to those prepared and published by the Committee on Examinations of the Division of Chemical Education of the American Chemical Society.[1, 2, 3] Two tests have been written and published on the basis of the results of that survey.

Since biochemical knowledge has expanded considerably in the past nine years a new survey seemed desirable. The results of this study, which was completed in August, 1953, are here presented in summary form; a copy of the complete report may be obtained from the author. These data will be used as the basis for new forms of the A. C. S. Cooperative Test in Biochemistry.

Of the 450 questionnaires sent to colleges and universities in the United States and Canada, 389 (86 per cent) were returned. Of these, 295 carried data pertinent to the survey, the remaining 94 representing either an institution at which biochemistry is not taught or a specialized graduate course not within the scope of the survey. Therefore, this report is based on 295 courses in 264 different institutions. Eighty-six of these courses are given at medical (71), dental (9), and pharmacal (6) colleges; 111 are offered by the larger public and private universities and technical schools (designated "Univ." in the report); and 98 are taught at liberal arts (L. A.) colleges. Nine general courses given by medical colleges for students in ancillary fields are included in the data for the universities. The vocational goals of the students enrolled in these institutions are given in Table 1.

In addition to general chemistry, which is required by all institutions, the following chemistry courses were listed as prerequisites for the study of biochemistry by the numbers of institutions given: qualitative analysis, 54; quantitative analysis (1 sem.), 136, (2 sem.), 13; organic (1 sem.), 88, (2 sem.), 182; physical, 19.

The educational levels at which the beginning course in biochemistry is given are as follows (numbers of courses); graduate, 128; senior, 148; junior, 80; sophomore, 24; freshman, 1.

[1] King, K. C., and W. J. L. Wallace, "The 1947–48 college chemistry testing program," J. Chem. Educ., 26, 426 (1949).

[2] Ashford, T. A., "The testing program of the Division of Chemical Education of the American Chemical Society," *ibid.*, 25, 280 (1948).

[3] Pritham, G. H., "Survey of courses and construction of tests in biological chemistry," *ibid.*, 22, 84 (1945).

TABLE 1
Vocational Goals of Students in Biochemistry Courses

Vocational goal	*Med.*		*Univ.*		*L. A.*		*Total*		
	No. of stud.	*No. of courses*	*No. of stud.*	*No. of courses*	*No. of stud.*	*No. of courses*	*No. of stud.*	*Per cent*	*No. of courses*
Agric.[a]	1	1	530	34	0	0	531	4.0	35
Bact.	67	16	293	49	60	20	420	3.2	85
Biochem.	99	24	309	52	173	38	581	4.4	114
Botany	18	3	136	36	48	8	202	1.5	47
Chem. (excl. Biochem.)	61	8	372	64	231	51	664	5.0	123
Dentistry	1036	17	57	25	65	27	1158	8.7	69
Home Ec. (incl. Nutrition)	10	1	642	46	278	45	930	7.0	92
Medicine (in Med. Sch.)	6049	70	0	0	0	0	6049	45.6	70
Pre-med.	22	2	415	51	316	57	753	5.7	110
Med. Tech.	50	7	234	36	215	50	499	3.8	93
Pharmacy	324	10	238	21	90	9	652	4.9	40
Physiology	27	9	17	5	5	1	49	0.4	15
Vet. Med.	64	1	270	6	0	0	334	2.5	7
Zoology	23	4	166	41	83	28	272	2.0	73
Others[b]	100	14	52	10	29	3	181	1.3	27
Totals	7951	86	3731	111	1593	98	13,275	100	295

[a] Chiefly Animal Nutrition, Agronomy, Horticulture, and Dairy Husbandry.
[b] Education, Food Tech., Nursing, and Pharmacology.

Of the 24 different textbooks in use, the leading six were listed, respectively, by 92, 61, 51, 39, 28, and 22 institutions. Despite the fact that instructors at 92 institutions, chiefly medical colleges, prepared their own mimeographed laboratory manuals, 23 different printed manuals are in use. Of these, four predominate, being listed respectively by 62, 29, 26, and 15 institutions.

The figures in Table 2 indicate that there has been little change in the length of courses in biochemistry during the past nine years, as the percentages of each type of institution in which a course of a given length is offered are nearly the same as they were in 1944.[3] The total number of class periods devoted to lecture and/or recitation likewise showed little change, as the average times are 67.7 "hours" (50-minute periods) in medical colleges, 54.6 in universities, and 46.9 in liberal arts colleges. The ranges are somewhat broader, however, as courses vary from 30 to 192 "hours" (mode = 60–80) in medical colleges, from 15 to 144 (mode = 30–54) in universities, and from 15 to 162 (mode = 42–54) in liberal arts colleges. At one medical college no formal lecture work is given.

The total laboratory time varies from 60 to 384 "hours" (mode = 120–124) in medical colleges, from 24 to 216 periods (mode = 60–112) in universities, and from 24 to 216 (mode = 32–54) in liberal arts colleges. Laboratory work is not given at one medical college, at 16 universities and at seven liberal arts colleges.

TABLE 2
Length of Course

Weeks	*Med.*	*Univ.*	*L. A.*	*Total*
10–12	4	20	10	34
14–19	43	47	67	157
20–26	27	11	4	42
30–36	11	33	17	61
64	1	...	..	1
TOTALS	86	111	98	295

The data in Table 3 indicate considerable variation in the relative amounts of time devoted to the various topics by the three types of institutions. In an attempt to make the test more adaptable to these differences in emphasis, future forms of the A. C. S. Cooperative Test in Biochemistry will be organized into four parts, *viz.*: (*a*) topics common to one-semester (or quarter) courses and to the first semester (or quarter) of year (or two-quarter) courses; (*b*) topics included only in the first semester of year-courses; (*c*) topics common to one-semester courses and to the second semester of year-courses; (*d*) topics included only in the second semester of year-courses.

TABLE 3
Total and Average Distribution of Lecture Time

	Med. (N = 84)			*Univ. (N = 101)*			*L. A. (N = 90)*			*Total (N = 275)*[a]		
Topic	*Hrs.*	*Av.*	*Per cent*	*Hrs.*	*Av.*	*Per cent*	*Hrs.*	*Av.*	*Per cent*	*Hrs.*	*Av.*	*Per cent*
Carbohydrates	417	5.0	7.3	661	6.6	12.0	496	5.5	11.8	1,574	5.7	10.2
Lipids	295	3.5	5.2	385	3.8	7.0	373	4.1	8.9	1,053	3.8	6.9
Proteins	511	6.1	9.0	733	7.3	13.3	502	5.6	11.9	1,746	6.4	11.3
Enzymes	288	3.4	5.1	346	3.4	6.2	226	2.5	5.4	860	3.1	5.6
Biocolloids	92	1.1	1.6	116	1.1	2.0	79	0.9	1.9	287	1.0	1.9
Physical chem.	349	4.2	6.2	254	2.5	4.5	178	2.0	4.2	781	2.9	5.1
Nutrition	243	2.9	4.3	211	2.1	3.8	160	1.8	3.8	614	2.2	4.0
Vitamins	254	3.0	4.5	279	2.8	5.1	249	2.8	5.9	782	2.8	5.1
Digestion	352	4.2	6.2	298	3.0	5.4	307	3.4	7.2	957	3.5	6.2
Micrometabolism	15	0.2	0.2	92	0.9	1.7	72	0.8	1.7	179	0.7	1.2
Plant metabolism	13	0.2	0.2	124	1.2	2.3	51	0.6	1.2	188	0.7	1.2
Animal metabolism	910	10.8	16.0	683	6.8	12.4	371	4.1	8.8	1,964	7.2	12.7
Hormones	270	3.2	4.7	195	1.9	3.5	160	1.8	3.8	625	2.3	4.1
Blood	527	6.3	9.3	284	2.8	5.2	278	3.1	6.7	1,089	4.0	7.1
Urine	308	3.7	5.4	166	1.6	3.0	186	2.1	4.5	660	2.4	4.3
Biol. oxidation	169	2.0	3.0	200	2.0	3.6	148	1.7	3.5	517	1.9	3.4
Respiration	192	2.3	3.4	166	1.6	3.0	129	1.4	3.1	487	1.8	3.2
Chemotherapy	35	0.4	0.6	54	0.5	1.0	70	0.8	1.7	159	0.6	1.0
Antibiotics	24	0.3	0.4	48	0.5	0.9	41	0.5	1.0	113	0.4	0.7
Antimetabolites	44	0.5	0.8	56	0.5	1.0	38	0.4	0.9	138	0.5	0.9
Ion-H_2O balance	87	1.0	1.5	19	0.2	0.35	1	0.01	0.02	107	0.4	0.7
Minerals	29	0.3	0.5	19	0.2	0.35	17	0.2	0.4	65	0.2	0.4
Tissues	44	0.5	0.8	21	0.2	0.4	18	0.2	0.4	83	0.3	0.5
Others[b]	224	2.6	3.8	95	1.0	1.8	58	0.6	1.3	388	1.4	2.3
Hours for average course	5692	67.7	..	5510	54.6	..	4208	46.9	..	15,410	56.2	..

[a] Twenty responses failed to include sufficient data.
[b] Anal. methods, foods, nucleic acids, detoxication, energy metab., acid-base bal., isotopes, photosynthesis, plant pigments.

Proceedings of the

PACIFIC SOUTHWEST ASSOCIATION OF CHEMISTRY TEACHERS

PHYTOSYNTHESIS: FIRST REACTIONS[1]

ANDREW A. BENSON
University of California, Berkeley, California

THE reactions of phytosynthesis include all metabolic reactions in the plant which result in the synthesis of organic compounds. Of primary importance among these are the reactions of photosynthesis which store the energy of light as chemical energy by converting carbon dioxide and water through a series of intermediate compounds to carbohydrate and oxygen. Thus photosynthesis supplies both the materials and the energy for all other reactions of phytosynthesis.

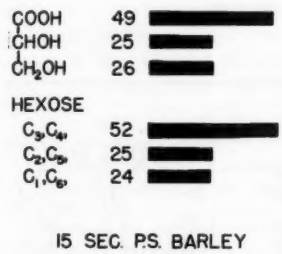


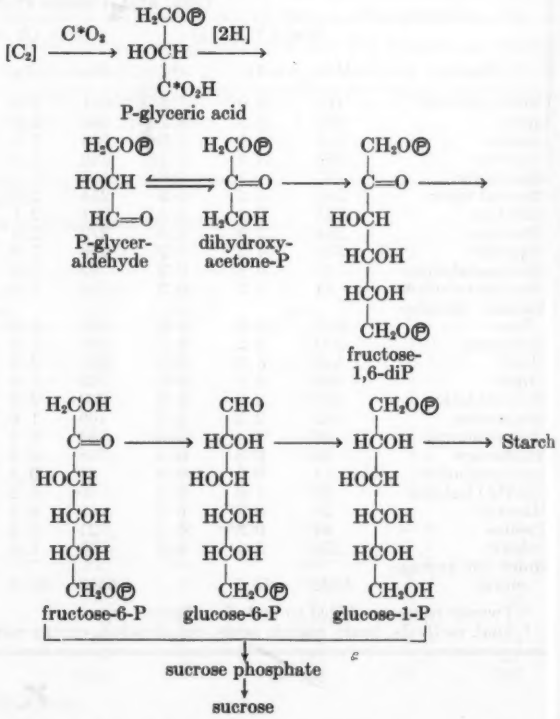
Figure 1. C^{14}-distribution in Phosphoglycerate and Hexoses Formed During 15 Seconds Photosynthesis by Barley Seedling Leaves

The studies of photosynthetic $C^{14}O_2$ fixation in this laboratory have now led to an understanding of the first steps of carbohydrate synthesis. From these few compounds are derived the multitude of compounds in the plant.

The fundamental process of photosynthesis is the conversion of electromagnetic energy of the light quantum to chemical energy of the reducing agent(s) required for carbon dioxide reduction. A plausible proposal for the mechanism of this puzzling process has been advanced from our laboratory[2] and is supported by a growing collection of circumstantial, if not positive, evidence. It is the function of this photochemically produced reducing power in phytosynthesis to which this survey is addressed.

The major first product of $C^{14}O_2$ fixation by all plants is carboxyl-labeled phosphoglycerate. Phosphoglyceric acid (PGA) becomes the major radioactive product. The first hexoses formed are 3,4-labeled. This indicates that two C_3 molecules condense, head to head, to give a C_6. As time progresses, the α and β carbons of PGA acquire C^{14} and the 1,2- and 5,6-carbon atoms of the hexoses become labeled. The typical distribution of label is given in Figure 1. Such data are obtained by chemical degradation of pure radioactive compounds separated from each other by two-dimensional paper chromatography.

It is now clear that the plant has made sucrose by a sequence of reactions similar if not identical to the process of glycolytic breakdown of sugars in animal tissue and yeast. In fact, each of the intermediates has been identified and observed to acquire radioactivity in the sequence shown below.



As radiocarbon saturates successive reservoirs of

[1] Based on a paper given at the meeting of the Southern Section of the Pacific Southwest Association of Chemistry Teachers, December 5, 1953, Immaculate Heart College, Los Angeles.

The work described in this paper was sponsored by the U. S. Atomic Energy Commission.

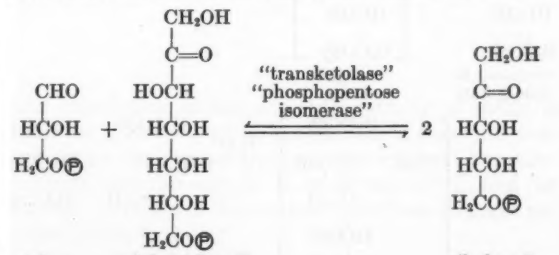
This paper is a review of recent work in this laboratory, most of which is described in more detail elsewhere; BASSHAM, J. A., A. A. BENSON, L. D. KAY, A. Z. HARRIS, A. T. WILSON, AND M. CALVIN, *J. Am. Chem. Soc.*, **76**, 1760 (1954).

[2] CALVIN, M., *Chem. Eng. News*, **31**, 1622, 1735 (1953).

these intermediates it would be expected that specific radioactivity (concentration of C^{14}) would be greater for fructose phosphates than for glucose phosphates. This is verified experimentally by an examination of the earliest labeled sucrose. Upon acid hydrolysis and chromatography of the two hexoses, the fructose moiety contained the greater part of the C^{14} (Figure 2). The exact mechanism of the enzymatic synthesis of sucrose is being studied in several laboratories and soon may be well understood.

The carboxylation reaction by which phosphoglycerate is formed from CO_2 and some constantly generated acceptor molecule has occupied our attention for some time. The biochemistry of microbiological or animal metabolism offered few clues to the nature of the cyclic process for making the carboxylation substrate. Such clues appeared in radiograms of short photosynthesis in $C^{14}O_2$.

The intermediates of sucrose synthesis were not the only phosphorylated sugars to acquire label in the first seconds of photosynthesis in $C^{14}O_2$. Sedoheptulose, previously found only in succulent plants such as sedums, and ribulose, known only as an uncrystallized synthetic sugar, became labeled in all photosynthetic organisms. They had not been observable before the advent of the tracer method with its great sensitivity for detecting their low concentrations (10^{-4} M) and the paper chromatographic method for separating efficiently the numerous sugars and their phosphate esters. The stereostructure of sedoheptulose and ribulose bears little relationship to that of the hexoses. By splitting a glycolaldehyde fragment (C_2) from sedoheptulose, however, one obtains ribose, the epimer of ribulose. Further, ribulose might lose a C_2 to give triose, which we see is the reduction product of PGA. These relationships led to the discovery of a ubiquitous enzyme system, transketolase, in laboratories of B. L. Horecker[3] and E. Racker. Their discovery of the transketolase enzyme supported and clarified our proposal of its function in photosynthesis. With transketolase, the acyloin-type cleavage of ketoses allows a transfer of glycolyl groups from one phosphorylated aldose to another.



These phosphorylated sugars have been isolated from the products of brief $C^{14}O_2$ fixation experiments and chemically degraded to determine the C^{14} distribution

[3] Horecker, B. L., P. Z. Smyrniotis, and H. Klenow, *J. Biol. Chem.*, 205, 661 (1953).

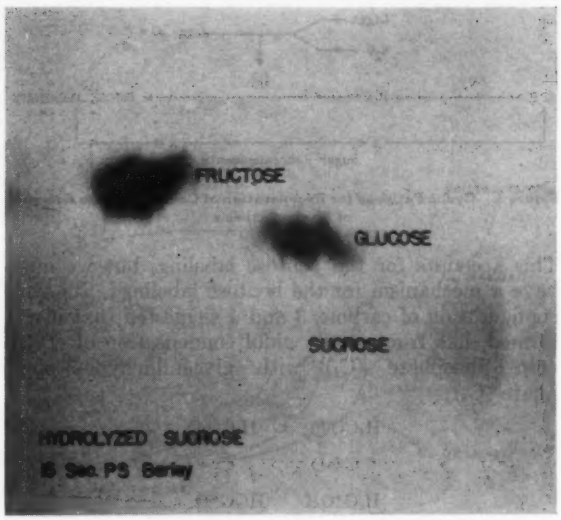
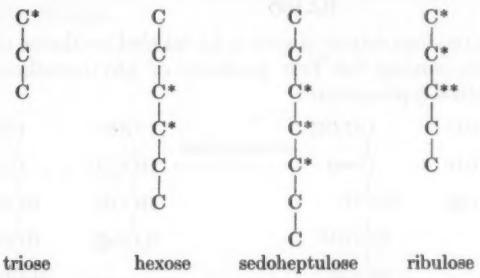
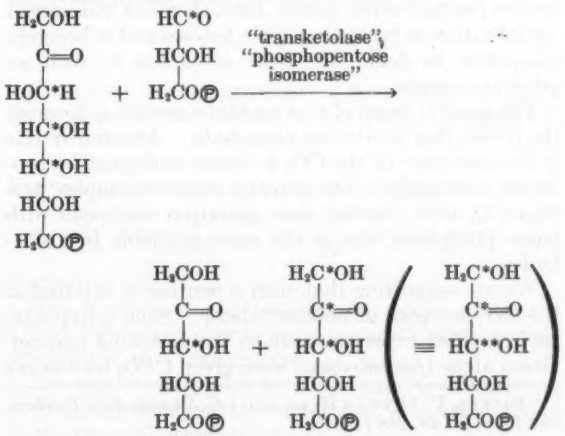


Figure 2. Hydrolysate of Sucrose Formed During 15 Seconds Photosynthesis in $C^{14}O_2$ by Barley Seedling Leaves

within each molecule. The results for products of the first few seconds of photosynthesis are schematically summarized:



In time, of course, they all become uniformly C^{14}-labeled. The observed labeling of the C_5 molecule does not appear to result from C_2 cleavage from C_7. Transketolase, however, catalyzes C_2 transfer from C_7 to a C_3 aldehyde to give:



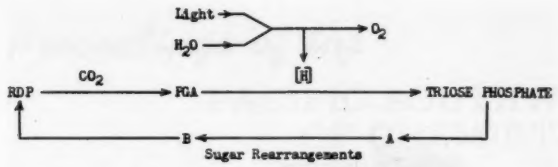
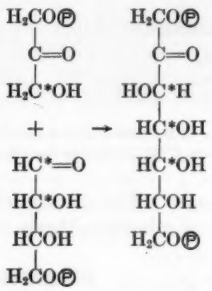
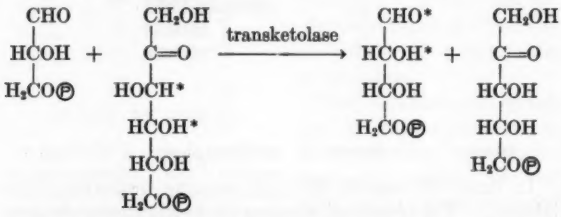


Figure 3. Cyclic Pathway for Regeneration of Carbon Dioxide Acceptor of Photosynthesis

This accounts for the pentose labeling, but we must have a mechanism for the heptose labeling. Its *trans* configuration of carbons 3 and 4 suggested that it was formed, like fructose, by aldol condensation of erythrose-4-phosphate (C_4) with glyceraldehyde-3-phosphate (C_3):



The obvious source of such a 1,2-labeled erythrose phosphate among the first products of phytosynthesis is fructose-6-phosphate.



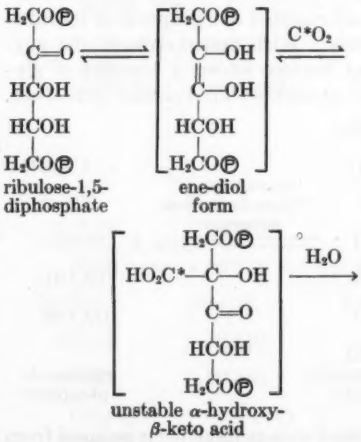
This hypothesis was elegantly proved by E. Racker, *et al.*,[4] with crystalline transketolase and pure fructose-6-phosphate. As soon as the plant has produced some labeled fructose-6-phosphate, then, there is a widespread equilibration of label among the ketoses and it becomes impossible to define the path of carbon in such an arbitrary system.

The general trend of this synthetic system is towards the production of ribulose phosphate. Apparently this is the precursor of the CO_2 acceptor and must be produced constantly. The glycolyl enzyme complex produced by each transketolase operation condenses with triose phosphate, one of the most available free aldehydes.

We are suggesting that such a pentose is required as the CO_2 acceptor of photosynthesis. Such a hypothesis is verified experimentally in the following manner. Green algae (*Scenedesmus*) were given $C^{14}O_2$ for twenty minutes, whereupon the reservoirs of the early photosynthetic intermediates became saturated with radiocarbon and the radioactivity in each compound became a measure of its concentration. In experiments by Mr. A. T. Wilson of this laboratory, the CO_2 pressure was suddenly dropped from 1 per cent to 0.003 per cent. Small samples of algae were withdrawn from the illumination vessel every five seconds and their components separated on paper chromatograms. The radioactive areas, defined by radiograms, were counted with a large-windowed Geiger tube. The concentration of phosphoglycerate and ribulose diphosphate showed profound changes. The concentration of phosphoglycerate, the carboxylation product, went down, as would be expected when the carboxylation step (Figure 3) was blocked. Ribulose diphosphate concentration, on the other hand, rose rapidly. When the CO_2 pressure is kept constant and the light is turned off the cycle is blocked at the reduction step and phosphoglycerate accumulates. Ribulose diphosphate and triose phosphate concentrations drop markedly. In fact, several oscillations in these concentrations were observed, as might be characteristic of any electrical or hydraulic closed circuit where an external condition is suddenly changed. Ribulose diphosphate is the largest C_5 reservoir of most plants and it seems to represent the outlet for ribulose-5-phosphate formed in the transketolase system. The phosphorylating power somehow developed during photosynthesis drives this synthesis:

$$\text{Ribulose-5-P} + \text{ATP} \rightarrow \text{Ribulose-1,5-P} + \text{ADP}$$

In considering ribulose-1,5-diphosphate as a possible CO_2 acceptor we notice that it cannot assume a ketal form, as does fructose diphosphate, but must have a true carbonyl group. This might well enolize and add carbon dioxide to form an unstable α-hydroxy-β-keto acid.



Hydration of the C_2-C_3 bond in such a keto acid should be possible and would lead to one molecule of labeled phosphoglycerate and one unlabeled one. As time of photosynthesis with $C^{14}O_2$ progresses the acceptor be-

[4] Racker, E., G. de la Haba, and I. G. Leder, *Arch. Biochem. and Biophys.*, **48**, 238 (1954).

comes labeled and both phosphoglycerates contain C^{14}. The change in free energy of this reaction has been estimated to be -5 ± 5 kg.-cal. and is extremely favorable compared to many other possible carboxylation reactions. This possibility of low-energy carboxylation arises because of oxidation of C_3 from a $-CHOH$ to a $-COOH$ group. The cyclic system, then, is currently considered to be represented by Figure 4.

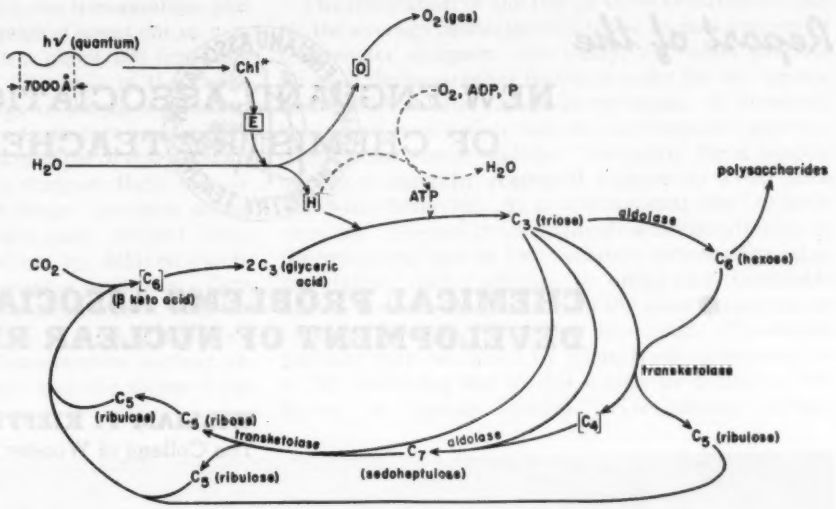


Figure 4. Proposed Cycle for Carbon Reduction in Photosynthesis

While the existence of such a mechanism for the primary CO_2 fixation step of photosynthesis is not yet certain,[5] it would seem that when biochemical transformations were being selected it should have merited the consideration of the plant world. It is particularly interesting that this reaction, through which almost all of the earth's reduced carbon passes, has not yet been clearly defined.

[5] It is now possible to reproduce the carboxylation step in a cell-free system (QUAYLE, J. R., R. C. FULLER, A. A. BENSON, AND M. CALVIN, *J. Am. Chem. Soc.*, **76**, in press (1954)). Radioactive phosphoglycerate was formed from $C^{14}O_2$ and ribulose diphosphate in the presence of a plant enzyme preparation.

ENTROPY CALCULATIONS AT LOW TEMPERATURE

GEORGE CALINGAERT
Hobart and William Smith Colleges, Geneva, New York

THE calculation of the absolute entropy of solids is based on a knowledge of specific heats from absolute zero up to the desired temperature. Actual measurements go down to only 50°K. or at best 10°K., and the student is advised in the textbook problems to make use of the Debye formula:

$$C = 465 \frac{T^3}{\theta^3}$$

to calculate the specific heat C between absolute zero and the lowest temperature at which C has been determined.

Since this evaluation of C is only incidental to the calculation of the desired entropy S, it may be by-passed altogether, using the following considerations:

θ is a constant characteristic of the substance; hence for any particular substance the Debye formula is:

$$C = KT^3$$

Expressing the entropy S and integrating, we obtain:

$$S = \int_0^T \frac{C}{T}\,dt = \int_0^T \frac{KT^3}{T}\,dt = \int_0^T KT^2 dt = \frac{1}{3}KT^3 = \frac{C}{3}$$

Stated in words:

The entropy at any temperature up to which the Debye formula applies is equal to one-third of the specific heat at that temperature.

The relationship must no doubt have been made use of in calculations, but no reference to it has been found in the physical chemistry textbooks.

Report of the

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS

CHEMICAL PROBLEMS ASSOCIATED WITH THE DEVELOPMENT OF NUCLEAR REACTORS[1]

WILLIAM F. KIEFFER[2]
The College of Wooster, Wooster, Ohio

ATOMIC energy has been making the newspaper front pages into science classrooms and vice versa for over eight years. In recent months many of the promises rather than the horrors have held the headlines. More and more laymen are coming to understand what the scientist means when he predicts that a genuinely peaceful world will be able to witness a "beating of swords into plowshares" on a scale never before dreamed of. It is hoped that the present discussion can serve the dual purpose of making available to chemistry teachers some of the pertinent information about reactors and about the role that chemists and chemical engineers play in the research that is needed to make industrial nuclear power a reality.

The United States Atomic Energy Commission's concern with the development of ultimate commercial power reactors has been widely publicized. Industrial teams have made feasibility studies of the economics of a variety of reactor types.[3] One after another of the experimental reactors have operated successfully. Breeding new fissionable material concurrent with power production is no longer a mere theoretical prediction. The respectable power level of 1000 kilowatts has been attained by one experimental model of a homogeneous reactor.

Security regulations do not allow any treatment of this topic to be amplified with many specific illustrations. Much of the information about reactors is empirical, gained by expensive and time-consuming research. It is very difficult at this time to say what is unimportant to the weapons program. However, it is possible to consolidate much pertinent qualitative information from the open literature.

Chemists are called upon to do a great variety of research in the development of reactors. The theoretical physicist, and after him the design engineer, keeps up a constant clamor for new types of materials and accurate knowledge about existing substances which the chemist must provide. The ultimate success of the whole reactor program will certainly depend upon its economic feasibility. These economies, both "neutron" and "dollar" economies, as Pitzer has stated, are the paramount problems for chemistry to solve. The implications of the term "dollar" economy are the old familiar ones, akin to those surmounted by any chemical industry in profitable existence. The term "neutron economy" is much less familiar to chemists. It is appropriate, then, to begin this discussion with a brief glance at some of the physical phenomena which are pertinent background.

FUNDAMENTALS OF REACTOR OPERATION

A nuclear reactor is an engine which consumes fuel to deliver energy. The primary source of energy is the highly unconventional fission of nuclei. The delivery of the energy is essentially the conventional process, since current designs for reactors provide only for the removal of heat. It is conceivable that the reactor of the future may use some of the tremendous amounts of gamma radiation directly to produce chemical reaction. Power production, however, involves only heat-exchanger devices. Their operation and maintenance is greatly complicated by the presence of other intense radiation.

The anatomy of the fission process need not be expounded here; a brief outline with the aid of Table 1 will suffice. The three currently considered fuels are U^{235}, Pu^{239}, and U^{233}. The first is obtained from natural uranium by isotope separation processes, the last two from the "breeding" process of neutron capture by U^{238} and Th^{232}, respectively.

Each fission act produces approximately 200 million electron volts of energy. It may be enlightening

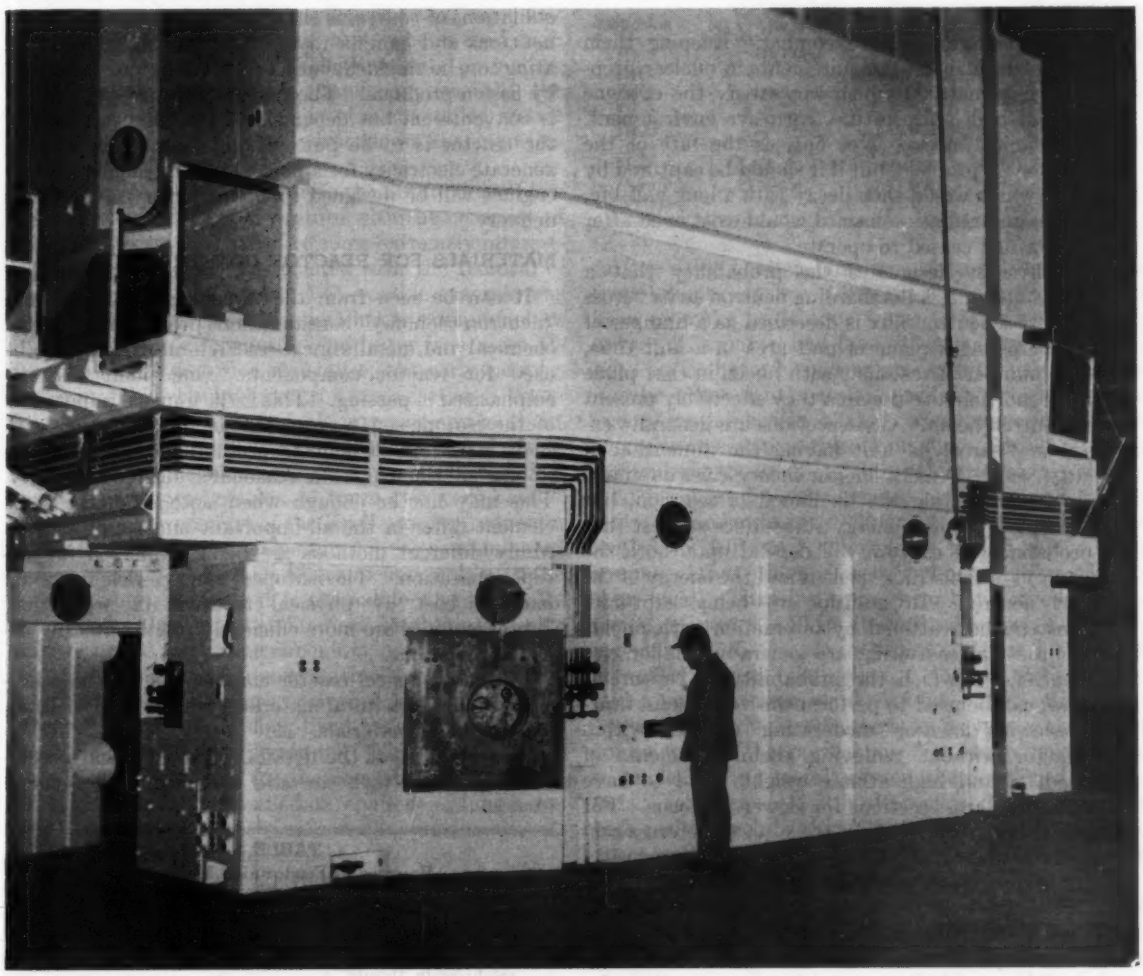
[1] Presented at the 15th Summer Conference of the New England Association of Chemistry Teachers at Bowdoin College, Brunswick, Maine, August, 1953.

[2] Research Participant in the Chemistry Division of the Oak Ridge National Laboratory, 1951–52.

[3] *Nucleonics*, 11, No. 6, 49 (1953).

to recall that the creation of an electron-positron pair represents the conversion into mass of about one m. e. v. of energy and that this in turn is about 200 times the energy of chemical bonding. The bulk of the fission energy appears as kinetic energy of the massive fission fragments. Because the fission fragments usually have more neutrons than the natural isotopes of equal atomic number, their nuclei tend to readjust their proton-neutron ratios by radioactive decay. As soon as fission fragments are formed, some eject "prompt" neutrons almost immediately, others by delayed mechanisms. The same is true of gamma emissions. Beta decay contributes probably only about 5 m. e. v. of the 20 m. e. v. indicated. The 10 m. e. v. labeled "absorbed neutrons" comes from the miscellaneous nuclear reactions involving stray neutrons with the atoms of the reactor core and structure.

The disposition of the two or three neutrons set free by the average fission process is the biggest concern of the reactor designer. Obviously, one must produce for each fission another fission in order for the reactor to be "critical" and remain in operation. If, however, the initiation of fission were the only fate for neutrons, the reactor would explode. Criticality for a reactor implies a carefully regulated balance to avoid such bomb-like behavior. It is obvious that the "neutron economy" referred to above involves the distribution of the remaining one or two neutrons between the other two fates: useful capture to breed new fissionable nuclei, and loss by escape from the zone of reaction or by parasitic capture in the machine itself. The escape problem may be solved by geometrical considerations or by modifying the reactor design to include a "reflector" or "breeder blanket." The parasitic-capture



Materials Testing Reactor

View of the massive shielding showing the ports for experimental purposes. This water-cooled heterogeneous reactor uses enriched uranium fuel. It develops 30,000 kilowatts of power from a neutron flux of 2×10^{14} in an active volume of only 100 liters.

TABLE 1
Outline of the Fission Process

$n + \left\{\begin{matrix}U^{235}\\Pu^{239}\\U^{233}\end{matrix}\right\} \rightarrow$	Energy (200 m. e. v.)	160 m. e. v.	Kinetic energy of fission fragments
		5 m. e. v.	Prompt neutrons
		5 m. e. v.	Prompt gammas
		20 m. e. v.	Radioactive decay series
		10 m. e. v.	Absorbed neutrons
	2 Fission fragment nuclei	> 40 different pairs possible	
		Decay to stable nuclei by 75 different chains	
		Propagation of fission chain reaction	
		Breeding of new fissionable nuclei	
	2–3 Neutrons	$U^{238} \rightarrow Pu^{239}$	
		$Th^{232} \rightarrow U^{233}$	
		Losses by capture or escape	

Fission process

losses are more difficult to combat. Keeping them small dictates stringent requirements in nuclear properties for any material which can satisfy the extreme demands of high temperature, corrosive environment, and mechanical stress. Not only is the fate of the neutron itself a problem, but if it should be captured by a nucleus which would then decay with a long half-life, a complicating radiation hazard would exist even after the reactor had ceased to operate.

The physicist designates the probability that a nucleus can capture a bombarding neutron as its "cross section." If a neutron flux is described as a number of neutrons crossing a plane of unit area in a unit time, then the number of reactions with nuclei in that plane will be proportional to the area they effectively present to the neutron beam. Cross sections are generally expressed in "barns," a unit having the dimension of 1×10^{-24} cm.[2] Present nuclear theory gives no simple picture for predicting the likelihood of reaction, but the concept of nuclear energy states does suggest that the probability of capture will depend upon both the constitution of the struck nucleus and the energy of the incident neutron. In addition to being captured, neutrons can be scattered by interaction with nuclei. Probabilities for scattering are generally smaller, yet light nuclei, for which the probability of capture is very low, can be used to perform the very useful function of slowing down or "moderating" neutrons within the reactor without removing them. Elements of intermediate and high atomic weights tend to have larger capture cross sections for slower neutrons. For neutron energies up to about 0.1 e. v. these cross sections are inversely proportional to neutron velocity. This range includes "thermal" neutrons (about 0.025 e. v.). From 0.1 to 1.0 e. v. cross sections vary greatly, often being very large for particular neutron velocities which correspond to resonance with nuclear energy states. Most nuclei have very low cross sections for high-energy neutrons, yet a few important exceptions occur. One is the large capture cross section for U^{238} at about 5 e. v. This fact makes it possible to plan a "breeder" reactor to make plutonium without having to incorporate a means of slowing down neutrons.

Space will not allow more than a very cursory review of the essential features of reactor construction. There is a great variety of designs differing in purpose, cost allowance, fuel type, etc. The "core" where fission occurs may be the size of a football or of a house; it may utilize natural uranium (0.7 per cent U^{235}) or highly enriched fuel. Usually the core also contains a "moderator" which serves to slow down neutrons to speeds at which capture to cause fission is most likely. In homogeneous reactors the medium in which the fuel is dissolved can also perform the moderating function; heterogeneous reactors require an additional component. Heat is removed by circulating a "coolant" (gas or liquid) through the core and through external heat exchangers; for a homogeneous reactor this can be the fuel solution itself. The bulkiest part of any installation, of course, is the shielding to protect against neutrons and gamma rays. Not only must the operating core be shielded, but also the radiations generated by fission products. The remainder of the installation is conventional but dependent upon the use to which the reactor is to be put. Huge steam turbines may generate electricity for a power station; smaller mobile engines will be designed for more concentrated power delivery.

MATERIALS FOR REACTOR CONSTRUCTION

It can be seen from the foregoing discussion that "neutron economy" considerations prompt much of the chemical and metallurgical research on materials to be used for reactor components. One point may be emphasized in passing. This is the unusual importance of the isotope-separation problem in connection with such materials. Chemists ordinarily are content to isolate an element to a reasonable degree of purity. This may not be enough when isotopes of the same element differ in the all-important nuclear properties. Many different methods are being employed for isotope separation. The isotopes of heavier elements are handled best by physical methods of separation; lighter isotopes are more efficiently fractionated by exchange reactions.

For convenience, reactor components will be classified as fuels, structural materials, moderators, coolants, and shielding materials.

Fuels. Most of the details of the chemical processing of reactor fuels are still classified. The general

TABLE 2
Sources of Fissionable Materials

Ore	*Estimated reserves (lbs. U and Th)*
High grade (>10% U and Th) pitchblende, thorite	10^6
Medium grade (1.0–0.1%) carnotite, monazite	10^9
Low grade (<0.1%) oil shale, sea water	10^{13}

principles of the gaseous diffusion method for U^{235} concentration are well known. The chemical problems of isolating manufactured fuel from breeder reactors will be touched on later. The pertinent data on fuel reserves are uncertain. Table 2 indicates to an order of some magnitude the reserves of various grades. Any chemist can read between the lines and visualize the magnitude and the direction of future chemical research as the problems of making available the world's natural resources of fissionable materials move toward the bottom of the table.

Structural Materials. Reactor construction presents a complicated variety of specifications for suitable materials. The conventional demands of high tensile strength, good heat transfer, creep resistance, etc., are accompanied by a demand for corrosion resistance under the most extreme conditions. The fundamental thermodynamics of reactor operation require high core temperatures for reasonable efficiencies. These may be accompanied by oxidizing atmospheres and high acidities or by contact with molten salts or metals. Some ceramic materials are promising, especially the "ceramets" where the addition of compounded metals greatly decreases a ceramic's brittleness and increases its heat-transfer qualities.

The reluctance to compromise the desirability of low cross section for neutron capture with the necessity of corrosion resistance has led to some extremely interesting chemical problems associated with the removal of the last traces of impurities. A notable example was the physicists' check on the metallurgists' manufacture of hafnium-free zirconium. The latter was most attractive for its corrosion resistance, but early samples had a prohibitively high neutron cross section. When it was discovered that hafnium's cross section was about 600 times that of pure zirconium, the impetus was provided for the development of a practical chemical method for the separation of these two very similar elements. The product of the Kroll process (reduction of the tetrachloride by magnesium) is too contaminated to be acceptable. The De Boer process starts with the Kroll product, converts it to the iodide, and thermally decomposes this on a hot filament to obtain a costly but very pure crystalline zirconium.

It is desirable to remove even traces of any impurity whose atoms may become activated to produce either intensely energetic or long-lived radioactivity which could be dangerous to personnel. This is particularly true of materials used for the construction of reactor parts which must be handled or repaired. Manganese, zinc, and cobalt, of the common alloying metals, are the chief offenders in this respect.

Radiation damage is a completely new phenomenon which requires that materials be tested under actual reactor conditions. The effect of intense gamma radiation on metals is minor. Damage results from collisions of high-energy fission products, and of neutrons to a lesser extent. When an energetic, relatively bulky atom hits a metal, the result is to produce a small localized hot spot, possibly accompanied by displacement of the crystal unit. The over-all effect approaches that produced by cold-working and hence its permanence will depend upon the annealing temperature of the metal. For ceramic materials the effects of thermal stresses are most detrimental. Much fundamental information about the solid state of matter is being accumulated as the testing of existing materials and the search for new ones proceeds.

At present, the choices from among the list of materials which have reasonably satisfactory properties for structural components of reactors represent compromises. Without detailing all of the pertinent data, it is interesting to compare some of these. Aluminum is in wide use, but its melting point (660°C.) and protective oxide coating limit its use to low temperature installations. It has a capture cross section of 0.22 barn to make an isotope whose gamma activity has only a 2.3-minute half-life. This means that it will not long be hazardous after exposure to neutrons. As for the other light metals, beryllium's poor ductility and potential health hazard, and magnesium's poor corrosion resistance rule them out. Stainless steels, particularly the 18–8 and Inconel varieties, are widely used because of their corrosion resistance and availability at moderate cost. Even so, their capture cross sections of 2.9 and 4.1 barns and the 45-day induced gamma activity in one iron isotope make steels less than ideal. Titanium appears to have excellent corrosion resistance, and its strength, ductility, and melting point (1725°C.) are promising. These advantages are offset by its relatively low thermal conductivity and a capture cross section of 5.8 barns. Zirconium appears on the horizon as the most promising structural component, if the purification from hafnium and the technology of its metallurgy can be developed to provide it for large-scale utilization at moderate cost. Its high melting point (1830°C.), excellent corrosion resistance, and a capture cross section of 0.18 barn make the pure element potentially very useful.

TABLE 3
Nuclear Properties of Possible Moderators

Substance	*Slowing-down power*	*Macroscopic cross section*	*Moderating ratio*
He	0.0009	0	Infinite
D_2O	0.18	36×10^{-6}	5000
BeO	0.11	0.0006	183
C	0.06	0.00036	165
Be_2C	0.16	0.0011	145
Be	0.16	0.0011	145
H_2O	1.36	0.022	62
Paraffin	1.24	0.020	62
NaOH	0.67	0.026	26

Moderators. For the choice of material for this reactor component, the nuclear properties are of greatest importance since most reactor designs incorporate a volume of moderator up to twenty times that of structural materials. Nuclei of low atomic weight are desirable because they allow a relatively larger energy loss per collision with the light neutrons. 1.0-m. e. v.

neutrons have speeds of 1.4×10^9 cm./sec., whereas thermal neutrons have been slowed to 2.2×10^5 cm./sec. This can be accomplished by 18 collisions with H nuclei, 90 with Be, or 114 with carbon. The slowing-down power of a material involves three factors: atomic density, neutron-scattering cross section, and a factor which depends upon energy loss per collision. The value of a moderator is better revealed, however, by the quantity designated as "moderating ratio" which is defined as the slowing-down power divided by the macroscopic capture cross section. Table 3 indicates the pertinent figures for some of the best moderators.[4] Again, chemists can read between the lines the implications of cost, purity, practical handling, etc., which represent challenges to chemical research. Reactor design often determines choice of moderator; for example, heavy water is much more costly, but its use allows a reactor to operate at much higher flux with fuel of lower enrichment, costing less. Organic hydrocarbons are cheap, but since they contain many more chemical bonds, they are very susceptible to radiation damage by both the gamma radiation and material particles. Similarly, H_2O or D_2O will be partially decomposed by radiation. Their use as moderators requires some provision for the safe recombination of the gases produced.

Coolants. Low capture cross section and high thermal conductivity are the two determining properties for choice of coolant material. Since the operating temperatures of reactors are high, liquid metals appear to be very attractive. Lead, bismuth, the alkali metals, and the 56 per cent NaK alloy are useful, but only with some structural materials in which they will not dissolve at elevated temperatures. Sodium and potassium also have induced radioactivities of fifteen and twelve hours which further complicate their handling. Chemists need no warning about the more conventional safety factors which must be incorporated in their manipulation. Some reactor designs incorporate a two-stage heat-exchange system in which the primary coolant does not come in direct contact with the steam-generating system. This has the obvious advantage of decreasing the amount of shielding for personnel safety. The circulation of an additional substance through the core to remove heat is obviated by the homogeneous reactor designs in which the solution of fuel serves the multiple purpose of moderator and coolant as well.

Shielding Materials. A whole treatise could be written on the problems of shielding alone. The variety of potentially harmful radiation emanating from a reactor precludes the choice of any one material to do the job. Fast neutrons must be provided for by allowing them to be inelastically scattered. This process usually produces gamma radiation, which in turn must be shielded. Heavy elements, Ta, W, Th, Pb, etc., are best. Intermediate neutrons are handled best by attenuation with moderator-type materials, such as H_2O. Thermal neutrons are most easily absorbed. Boron (capture cross section, 750 barns) and boron-steels are useful. The induced activity has an extremely short half-life so that it ceases almost immediately with reactor shutdown. The intense gamma radiation accompanying any reactor operation requires shielding by dense aggregates of high atomic weight atoms. Lead, bismuth, and barium concretes are useful. It is significant to recognize that gamma radiations follow a Beer's-law pattern of proportionality between the logarithm of intensity and thickness of absorber, so that any otherwise unprotected person can best be reassured by increasing the distance between himself and the source.

[4] EVANS, G. E., *Nucleonics*, 11, No. 6, 23 (1953).

CHEMICAL PROCESSING PROBLEMS

Whereas much of the chemical research involved in developing reactor materials is motivated by the demands of neutron economy, the research on chemical processing of spent reactor fuel relates more to meeting the pressures of dollar economy. Great strides toward this goal have been made. Plutonium was made at Hanford in 1951 for only half of what it cost in 1947 and it is still cheaper today. Some authorities feel that the economic feasibility of industrial power from nuclear fuel hinges on the practicality of simultaneously manufacturing new fuel and on the utilization of fission products. Partially depleted fuel is still so valuable that it must be recovered and reconverted to be used again. The manifold phases of chemical processing can be discussed under the headings of objectives, uniqueness, and methods.

Spent fuel is put into solution for treatment, the first objective of which must be the removal of fission products. The chief reason for this is that fission-product nuclei are responsible for the intense and most dangerous radiation. Once these are removed, the later stages of the processing can be carried out by more conventional means requiring less shielding. It also happens that certain of the fission-product nuclei have such high neutron-capture cross sections that they act as poisons for the operation of the reactor. Other poisons may grow in with time as a result of fission-product decay chains. All such nuclei must be removed completely before the fuel can be returned to the core.

Anyone who has looked at a copy of the General Electric Company's "Chart of the Nuclides" cannot help but be impressed by the great variety of squares with the little black triangles in the lower right corner, designating known fission products. Fission occurs in over forty different ways and produces at least 75 known decay chains with over 200 identified species of atoms. The distribution of isotopes is shown by the familiar double-humped, camel-back curve with peaks at mass numbers 95 and 139. A student in a qualitative analysis course would be dismayed to see that on the usual periodic table this would indicate that if he had such an unknown it probably would contain large proportions of the elements around molybdenum and the rare earths! If his periodic table were pre-1947 it would not even contain two of them, promethium and technecium. The accompanying Table 4 is not inclu-

sive, but will serve to indicate the variety of long-lived, highly-energetic radioactive fission products formed in appreciable yield.

Even such a table as this does not tell the whole story of shielding worries, however. Beta radiation is stopped much more readily than gamma. Often the container walls or the solution itself will eliminate it. Gamma radiation is much more penetrating. Although no gamma is evolved when Ru^{106} decays to the daughter Rh^{106}, the latter emits both betas and energetic gammas with a 30-sec. half-life. Such a short-lived daughter produces practically the same effect as if it had its parent's long life. Similarly, 12.8-day Ba^{140} goes to 40-hour La^{140}, which emits the very energetic 2.9- and 1.6-m. e. v. gammas. The fact that the first two elements of the table are gases implies a further potential hazard in operating a process where any volatile material may escape. After some weeks of standing, the main gamma activity comes from the 65-day Zr^{95} and its daughter, 35-day Cb^{95}.

The advantages of letting the solution "cool" in storage before attempting any operation are obvious. The rate of activity decrease is rapid but not so great as might be expected, chiefly because some intense activities grow in. The over-all intensity has been found to be approximately proportional to (time in days)$^{-1.2}$.

The only feasible method for handling such a complicated variety of trouble is to employ a technique which will take all of it out together. Precipitation from acid solution with carrier fluorides is one such nonspecific reaction employed. This can be followed by specific separations such as those now in use to obtain the active iodine and caesium isotopes for medical purposes.

The remainder of the chemical processing procedure (recovery of unused uranium and the separation of the plutonium) is one of the most demanding searches for a needle in a haystack that chemical engineering has ever faced. Since the first step in the plutonium-manufacturing chain is the capture of a neutron by U^{238} to form Np^{239}, it is revealing to estimate the fraction of the U^{238} atoms which might be expected to capture neutrons during one day's operation of a reactor. Choosing a flux of 10^{12} neutrons crossing a square centimeter each second (about 10^{17} per day) and an approximate cross section of 100 barns, the calculation shows the following:

$$\begin{aligned}\text{Fraction reacted} &= (\text{flux}) \times (\text{cross section}) \\ &= (10^{12}/\text{sec./cm.}^2) \times (100 \times 10^{-24}\ \text{cm.}^2) \\ &= (10^{17}/\text{day}) \times (10^2 \times 10^{-24}) \\ &= 10^{-5}/\text{day or 10 parts per million per day}\end{aligned}$$

This last figure means that only about ten out of every million uranium atoms are being started on their way toward becoming plutonium during each day that they remain in the reactor. Such a daily rate is so low that it poses a fantastic problem of product separation and uranium repurification. The advantages that might be expected by allowing the uranium to react for a long time and hence build up a high concentration of plutonium are offset by the accumulation of fission poisons and the fact that plutonium itself will begin to disappear by neutron capture and fission. Fortunately, the differences in oxidation potential for comparable valence states and the differences in the chemical behavior of the valence states of uranium and plutonium are sufficient to be taken advantage of in designing processes for separation. Large separation factors can be obtained by recycling, and wherever possible processes are made continuous.

The popular press has convinced everyone that the plant handling highly radioactive materials is an abode of fantastic robots for which "unique" is an understatement. The hard reality is that any operation requires from two to five times longer to perform under radiation conditions. Equipment design problems always involve biological shielding, remote mechanical operation, and the necessities of maintenance and repair. Shielding considerations suggest that large volumes be avoided wherever possible. One example of minimizing mechanical operating difficulties is to pump liquids through extractors with magnetically impelled centrifugal pumps in preference to processes involving the filtering of solids. Often it is difficult to know what is going on yards away behind shielding walls without the use of mirrors. Even here radiation increases the difficulty. Glass and quartz will discolor to opacity because of the electron displacements caused in them by gamma radiation. Many intricate and ingenious mechanical and electronic devices are being developed to take the place of useless conventional indicators for liquid levels, flow rates, etc.

Another unique aspect of the problem of processing spent fuel is the necessity for adhering to a fairly strict time table for operations. This time factor has already been seen to be a necessary consideration in the handling of fission products. An important requirement is set by the schedule on which the major breeder product manufactures itself from its precursor. In the

TABLE 4
Long-lived Fission Products Formed in High Yield

Nuclide	*Fission yield (%)*	*Half-life (days)*	*Beta activity (m. e. v.)*	*Gamma activity (m. e. v.)*
Xe^{133}	4.5	5.3	0.35	0.08
I^{131}	2.8	8.14	0.61	0.37, 0.28, 0.64
Nd^{147}	2.6	11.6	0.4, 0.8	0.58
Ba^{140}	6.1	12.8	1.0	0.54, 0.16
Pr^{143}	6.	14	1.0	...
Ce^{141}	5.7	33.1	0.58, 0.44	0.14
Nb^{95}	6.4	35	0.16	0.75
Ru^{103}	2.8	40	0.2, 0.7	0.56
Sr^{89}	4.6	53	1.5	...
Y^{91}	5.9	61	1.53	...
Zr^{95}	6.0	65	0.39	0.72
		(years)		
Ru^{106}	0.4	1	0.04	...
Pm^{147}	2.6	2.6	0.23	...
Kr^{85}	1.3	9.4	0.74	0.15
Sr^{90}	5.3	20	0.6	...
Cs^{137}	6.2	33	0.5, 1.2	0.66
Tc^{99}	6.2	2×10^5	0.3	...

plutonium production scheme, the initially formed U^{239} has a quick 2.3-minute half-life for decay to Np^{239}, but the latter decays with a slower 2.33-day half-life to Pu^{239}. This means that it will be nearly two weeks before 98 per cent of the product, Pu^{239}, will be ready to isolate. The chain of events is somewhat longer for making U^{233} from Th^{232}. The final product, U^{233}, is created from the intermediate Pa^{233} at a 27.4-day half-life rate. This means that breeding U^{233} is bound to be time-consuming. A month's standing will still allow only about half of the possible U^{233} to be formed from the Pa^{233} which is present.

Merely waiting for things to happen is not always expedient. The variables of chemical behavior which are time-dependent go far beyond the transformation of certain species of atoms. When the material is in solution, either aqueous or in organic solvents, radiation decomposition of the solvent is bound to occur if appreciable amounts of gamma radiation are present. Many of the equilibria between forms of hydrated and complexed ions in the variety of valence states possible have kinetics which demand time considerations. Hydrolyses are quite sensitive to acidity and temperature in many cases. It is difficult to redissolve hydrated oxides once they have been precipitated.

In addition to the difficulties of the chemistry involved in extracting and isolating such minute quantities of breeder product from spent fuel, there are the demands for extreme purity of reagents and the unusual degree to which reactions must be "carried to completion." In some cases these demands arise from biological considerations. The health of operating personnel must not be subjected to the hazard of ingesting even minute quantities of certain elements or compounds. The estimate is that one microgram of plutonium is an allowable lifetime dose for a person. Such circumstances require not only equipment that will not break down, but operators with whom mistakes are equally improbable.

There is one final unusual feature which must be recognized by the designer of a reactor's chemical processing plant. This is that nowhere in his maze of tanks, pumps, pipes, and shielding can he allow the accumulation of sufficient fissionable material to attain a critical mass. Even the unexpected precipitation of a large amount of fissionable material from its more highly dispersed condition in solution could be dangerous. This can be avoided most surely by keeping volumes small and surrounded by efficient neutron absorbers such as boron or cadmium.

PROCESSING METHODS

The potential methods for accomplishing the tasks assigned to the chemical processing plant can be briefly outlined.

Precipitations. The separation of trace materials by carrier precipitations is historically important for the successes it achieved in the early Hanford plutonium production. Inorganic precipitates generally are resistant to radiation damage. The chemistry involved is basically familiar, as is the equipment necessary for its handling. It is, however, almost always a batch process with inherently high operational cost, and subject to more maintenance problems than other methods. In addition, there is the fundamental limitation imposed by species concentration on the completeness of any reaction with corresponding finite losses. Recovery by recycling is complicated.

Ion Exchanges. These methods, either for cations or anions, can be adapted for continuous processing and are less likely to involve maintenance complications. It is possible to remove a particular species almost completely since distributions are not dependent on concentration. The use of efficient synthetic-resin exchangers is somewhat limited by the inherent susceptibility of any organic material to radiation damage. Exchange equilibria are influenced by a variety of changes in conditions which affect the valence state, degree of hydrolysis, etc., of the ionic species, so that careful control is necessary.

Solvent Extractions. Many compounds ordinarily thought of as being only water-soluble are found to have quite appreciable solubilities in organic liquids. If such an organic liquid is immiscible with water, it can be run counter-currently to an aqueous solution to achieve the extraction of the solute. Chemical industry has perfected machinery to do this so that its use promises to minimize the problems of remote control and maintenance. Another factor favoring this method is its adaptability to continuous processing at reasonable cost. As with ion-exchange equilibria, partition ratios can be manipulated to remove all but an extremely small concentration of a particular species. Reversals are convenient to accomplish. There are limitations imposed by the miscibility, volatility, solvent properties, and potential radiation decomposition of organic liquids.

Electrodepositions. Such methods can be adapted to continuous operation, as a result of the experience of existing industrial installations. Although remote control is possible and maintenance conceivably simple, the cost probably would be high. Another disadvantage would be the difficulty of regulation to accomplish a specific separation.

Distillations. Equally adaptable to continuous and remotely controlled installations, the application of these methods is limited to systems in which clear-cut distinctions can be made. Liquid solvents could be evaporated off from solutes, or compounds with widely different boiling points could be separated efficiently.

NUCLEAR FISSION AS AN ENERGY RESOURCE

No discussion of the status of reactor development can be concluded without quoting the figures of Putnam, which so forcefully state the case for the future. Using the symbol Q to represent 1×10^{18} B.t.u., the world's energy use from the year 1 A.D. to the time of the industrial revolution is estimated to have been 6 to 9 Q. From 1860 to 1947, 4 Q were used. The last half of the present century will probably consume 20 Q

and the curve will climb to a rate of 100 *Q* for the twenty-first century. Our fossil fuel reserves are dwarfed by these figures: 68 *Q* of coal (only about 6 economically recoverable) and less than one *Q* of gas and oil. Uranium and thorium move into a new status as natural resources of energy without much manipulation of these figures. Estimates vary as to how soon the world will be forced to rely upon them. The estimates of potential energy in the world's resources of uranium and thorium are tenuous at best. A figure of several hundred *Q* is generally agreed to be a reasonable expectation, on the assumption that fissionable fuel can be bred with good neutron economy. Ultimately, of course, it too will drop into a minor role compared to the inevitable harnessing of solar energy which future civilization will be forced to accomplish. The gap which appears between the foreseeable exhaustion of fossil fuels and the uncertain time of large-scale solar energy utilization undoubtedly will have to be filled by nuclear energy set free in power and power-breeder reactors.

The contributions of chemists and chemical engineers to solution of the problems of neutron and dollar economy in reactor development are adding another to the manifold tasks they are being called on to perform as conservationists of the world's natural resources.

BIBLIOGRAPHY

LANSING, N. F., Compiler, "The Role of Engineering in Nuclear Energy Development," United States Atomic Energy Commission, TID 5031, Technical Information Service, Oak Ridge, Tennessee, 1951.

GOODMAN, C., Editor, "The Science and Engineering of Nuclear Power," Vols. I and II, Addison Wesley Press, Cambridge, Mass., 1947.

GLASSTONE, S., "Sourcebook on Atomic Energy," D. Van Nostrand Co., Inc., New York, 1950.

EVANS, G. E., *et al.*, "Materials and Equipment for Reactors," *Nucleonics*, 11, No. 6, 18–48 (1953).

CAMPBELL, W. M., *Can. Chem. Processing*, 37, No. 4, 28 (1953).

NICHOLLS, C. M., AND A. S. WHITE, "Pilot plant problems of chemical engineering and atomic energy," *Chemistry & Industry*, No. 3, 51 (1953).

SLATER, J. C., "The effect of radiation on materials," *J. Appl. Phys.*, 22, 237 (1951).

PITZER, K. S., AND S. G. ENGLISH, "The role of chemistry in the development of atomic energy," *Chem. Eng. News*, 29, 4836 (1951).

MANNING, W. M., "Chemical problems in the development and operation of nuclear reactors," *Record Chem. Progr.*, 12, 117 (1951).

CORYELL, C. D., AND N. SUGARMAN, "Radiochemical Studies: The Fission Products" (National Nuclear Energy Series, Div. IV, Vol. 9), McGraw-Hill Book Co., Inc., New York, 1951.

PUTNAM, P. C., "Energy in the Future," D. Van Nostrand Co., Inc., New York, 1953.

BENEDICT, M., "Chemical engineering aspects of nuclear power," *Ind. Eng. Chem.*, 45, 2372 (1953).

To the Editor:

Recently my attention was called to the method of reclaiming silver from silver chloride residues as described by Mr. Otto L. Willbanks in THIS JOURNAL, **30**, 347 (1953). One of the members of our department had tried the method and was disappointed with the relatively small yields of silver oxide that he was able to obtain in relationship to the amounts of sodium hydroxide used.

There is nothing in Mr. Willbanks' article that suggests that the yield of silver oxide is poor. In fact, it would appear that the author's statement that silver chloride, under the given conditions, "furnishes 5000 times the silver ion concentration required for the precipitation of silver oxide," was meant to suggest that the reaction between silver chloride and sodium hydroxide is largely complete. Actually, the apparently large value of the ratio has little meaning in terms of the final equilibrium conditions, since the concentration of the silver ion is reduced more than 5000 times as soon as the reaction has progressed to a slight extent.

One may calculate at least roughly the extent of the metathesis of silver chloride by a solution of sodium hydroxide. At equilibrium both solubility product equations are simultaneously true:

$$[Ag^+][Cl^-] = 1 \times 10^{-10}$$

and

$$[Ag^+][OH^-] = 1 \times 10^{-8}$$

By simple division one obtains the ratio between the concentration of the chloride and of the hydroxyl ions.

$$[Cl^-] = [OH^-]/100$$

This result indicates that for every mole of sodium hydroxide used only one hundredth of a mole of silver would be obtained as silver oxide. In terms of grams the yield, one gram of silver for each 37 grams of sodium hydroxide, sounds somewhat better. However, in spite of the difference in the cost of sodium hydroxide and that of silver, this yield is hardly one that would delight the heart of a manufacturer of chemicals.

Mr. Willbanks indicates that the method may be used for the reclamation of other silver salts, such as the thiocyanate. The solubility product of silver thiocyanate is approximately one hundred times less than that of the chloride. Accordingly, to obtain one gram of silver from silver thiocyanate by this method, approximately 3700 grams of sodium hydroxide would be required.

WALTER R. CARMODY

SEATTLE UNIVERSITY
SEATTLE, WASHINGTON

To the Editor:

I have read with great interest the article titled "Industrial advertising as a source of information," by W. G. Kessel (THIS JOURNAL, **31**, 255 (1954)). From the point of view of instruction in the classroom this source of knowledge has no workable substitute. Teachers, by and large, are both *book-bound* and *classroom-bound*. They follow the book and they spend most of their days *in* the classroom. Textbooks, however up-to-date or modern, generally do little with industrial applications and developments. They spend their pages developing theory, and perhaps justifiably so. Reference might be made to an industry or to a product by way of fine print or a black-and-white photograph, but these are not worth much pedagogically. As for the teachers, they are constrained to the classroom. The so-called field trip with a class to a plant or factory is pitifully infrequent, but pretty nearly inescapably so. Since the student cannot easily be brought to the plant or to the product it appears both necessary and worth while to bring these to him. Industrial advertising does it in good measure. By this device new products, new processes, new words are discovered. There is no better source of the latest. And it is most certainly *not* in the textbooks.

A few years ago a colleague and I pursued a program which paid high in stimulation and enthusiasm personally, and which added immeasurably to our usefulness in the classroom. We reserved one afternoon a week to visit plants and industries—alone, not with classes. (This last is too difficult to "machine.") Our program was scheduled in advance. Our purpose—curiosity, knowledge, improvement in our teaching—was made clear to the plant administration. And they made our visits very fruitful. We took a great deal back to the classroom and our departure from the textbook was reflected in our teaching. I recommend this scheme to teachers generally and to physics and chemistry teachers particularly. So much of the technological world is hidden from our sight when we are bound to classroom and text.

JULIUS SUMNER MILLER

EL CAMINO COLLEGE
EL CAMINO COLLEGE, CALIFORNIA

To the Editor:

Doody and Gibbens (THIS JOURNAL, **31**, 11 (1954)) state, "The first report or two are liable to be awkward and stilted."

Ain't it the truth!

HUGO P. KORTSCHAK

HONOLULU, HAWAII

PROGRESS IN ORGANIC CHEMISTRY. VOLUME 2

Edited by *J. W. Cook*, Regius Professor of Chemistry, University of Glasgow, and Fellow of University College, London. Academic Press, Inc., New York, 1953. viii + 212 pp. 16 × 25.5 cm. $7.

THIS is the second volume edited by J. W. Cook of an apparently continuing series on "Progress in Organic Chemistry." The first volume appeared in 1952 (J. CHEM. EDUC., **29**, 639 (1952)) and the second volume follows the previously established pattern. The articles are concise rather than comprehensive and are of the same type as are to be found in *Chemical Reviews*. In each case the reviewer is a recognized authority on the subject of his chapter and one who has played an active part in its advancement.

The six chapters discussed in the present volume and their reviewers are: "Some recent developments in theoretical organic chemistry," M. J. S. Dewar; "Organic fluorine compounds," M. Stacey; "The chemistry of the triterpenoids," D. H. R. Barton; "The partial synthesis of cortisone and related compounds from accessible steroids," F. S. Spring; "The relation-

ship of natural steroids to carcinogenic aromatic compounds," H. H. Inhoffen; "Some recent developments in pyridine chemistry," J. P. Wibaut.

The average organic chemist will find the first chapter quite difficult to digest but should have no particular difficulty with the other chapters. The treatments are adequate and well organized. An attempt has been made to bring the literature references more nearly up to date than was the case in the first volume. Each chapter has a number of citations to the literature subsequent to 1950 but an abnormal proportion of these are to the authors' own publications. The extreme example is that of the fifth chapter wherein five out of 84 references are to publications since 1950 but all of these are to the author's own work! As in the case of the first volume the typography is good but the price seems high.

L. A. GOLDBLATT

United States Department of Agriculture
New Orleans, Louisiana

● LEHRBUCH DER ORGANISCHEN CHEMIE

Paul Karrer, Professor at the University of Zurich. Twelfth edition. George Thieme Verlag, Stuttgart, 1954. xx + 949 pp. 6 figs. 1 table. 20 × 27 cm. $14.20.

Professor Paul Karrer's "Lehrbuch der organischen Chemie," which first appeared in 1925, has gone through many editions. This, the twelfth and latest edition, aims to present a comprehensive and up-to-date account of organic chemistry. The literature coverage goes to early 1953. A check showed that recent developments in the chemistry of such compounds as aureomycin, cedrene, sterculic acid, caryophyllene, coenzyme A, and metal bicyclopentadienyl "sandwiches" are included. The work of Bijvoet on absolute configuration of tartaric acid is given. The treatment is especially thorough in the natural products areas. The emphasis on alkaloids and on heterocyclics is noteworthy. Thus, while other texts of a comparable nature devote less than 5 per cent of their page space to alkaloids and heterocyclics, the "Lehrbuch" devotes no less than 15 per cent to them. A short chapter dealing with isotopes in organic compounds is informative and welcome.

Although in general the author's presentation leaves little room for disagreement, some points to which exception is taken might be mentioned. For example, the formation of 1-bromo-3-chloropropane by addition of hydrogen bromide to allyl chloride, a reaction commonly accepted as a free radical process, is given on page 50 presumably as an ionic process, with the inductive effect of the chloromethyl group reversing the Markovnikoff addition. On page 269 the reader is left with the impression that, in the Claisen condensation of ethyl acetate, something other than neutral acetoacetate is the precursor of sodioacetoacetate. The Pummerer mechanism (page 273) for the acid-catalyzed conversion of hydroxymethylfurfural to levulinic acid has little to commend it. There is no real need to involve the hydrated aldehyde form as an intermediate in the mutarotation of glucose (page 324). The perbenzoic conversion of olefins to epoxides is a reaction of perbenzoic acid and not of its sodium salt (page 511). Linoleic and linolenic acid, although necessary food factors for the rat, have *not* been shown to be essential for normal growth in man (page 211). The description of quinoline as a weak base (page 783) is suitable, but the statement that isoquinoline is a "ziemlich starke" base (page 788) is not appropriate. Both compounds (K_b's 3.2×10^{-10} and 2×10^{-9}, respectively) are generally described as weak bases, certainly so in comparison with ammonia. Finally, the 1951 Roberts-Chambers synthesis of cyclopropanol by oxidation of cyclopropylmagnesium chloride is didactically more valuable than the Cottle synthesis, which is the one given (page 621).

A criticism more serious than any of the above-mentioned concerns the manner of dealing with stereochemistry. No one section is devoted specifically to stereochemistry as a general subject. Instead, and in keeping with the basic arrangement of the book according to class of compound, *i. e.*, to functionality, various aspects of stereochemistry are developed only when compounds calling for such development are encountered. For example, geometric isomerism is discussed briefly under olefins. The asymmetric carbon atom, optical activity, resolution (note that the work of Schlenk and of Powell on resolution by formation of inclusion complexes is presented), asymmetric induction, etc., are discussed in the section on alcohols after coming to "active" amyl alcohol. Asymmetry around nitrogen is presented under properties of amines. The Baeyer strain theory is found under glycols in connection with the stability of ring ethers. Restricted rotation is introduced in the section on compounds related to biphenyl. Stereochemical problems related to cyclopropane and cyclohexane are discussed briefly in the respective sections. Very little is done with the idea of conformation. The Walden inversion is introduced quite properly under the interconversions of α-amino acids. But the topic of nucleophilic substitution at a saturated carbon is disposed of in one-half page of fine print as a subtopic under the inversions of α-amino acids.

The subject of stereochemistry cuts across all of organic chemistry. As far as this reviewer is concerned, stereochemistry should be accorded the space and attention it deserves as a major topic in its own right.

The book is carefully indexed, 56 pages of three-column entries being occupied by the index. The detailed Table of Contents (12 pages) is likewise very useful in locating material. No specific references are given in the text. However, the practice is followed of mentioning pertinent names parenthetically. Also frequent references are made to books, treatises, and monographs.

The inclusion of such a large amount of material in one volume is made possible by presenting many sections in fine print. The readability is not impaired by this device. The paper, printing, and binding are excellent. Typographical errors are practically nonexistent. The book is massive not only in scope but also in size. It has oversize pages and weighs almost 5 pounds. It is not conveniently held on the lap.

The great virtue of the "Lehrbuch" is that it presents in a single volume an up-to-date and systematic array of facts about organic chemistry. This is the stated intent of Professor Karrer, and in this he has succeeded admirably. But however welcome the facts, many organic chemists will rue the de-emphasis of theory and of reaction mechanism. Within Professor Karrer's working frame of reference and the confines of a single volume the de-emphasis probably is unavoidable. However, this reviewer suggests that a better balance between description and interpretation—obviously at the expense of the former—would make the "Lehrbuch" an even more popular treatise than it is now.

Potential purchasers of the "Lehrbuch" should realize that an English translation is available (fourth English edition, Elsevier Press, 1950), and also that plans have been announced for publication of the English edition in two volumes (Elsevier Press).

WALTER J. GENSLER

Boston University
Boston, Massachusetts

● GENERAL COLLEGE CHEMISTRY

M. Cannon Sneed, J. Lewis Maynard, and *Robert C. Brasted,* University of Minnesota. Second edition. D. Van Nostrand Co., Inc., New York, 1954. vi + 693 pp. 16.5 × 23.5 cm. $6.50.

This second edition of a well known text certainly meets and perhaps exceeds the standard set by the first edition ten years ago. Its outstanding characteristic is clarity of expression. Too often, the textbook author writes as though he senses a fellow teacher looking over his shoulder with a critical eye. Here, the authors seem to be seated around a tutorial table with a group of inquisitive young students; their remarks are addressed to these

young people. No words are wasted in explaining the point at hand, yet there is no blunt terseness. The expositions are free and easy to read—in places almost poetic. The student who takes the trouble to digest the explanations can hardly fail to understand them.

Unfortunately, most of the illustrations do not match this excellence. As exceptions, the diagram of the open-hearth furnace, the comparative rigidity of Fe, Al, and Mg, the relation between humidity and comfort, the by-products of coal, the Hindenburg in flames, and J. A. Campbell's chart of atomic and ionic sizes are to be noted. But how much longer must we wait until our texts cease to use obsolete line drawings and cloudy half-tone reproductions? Mr. Van Nostrand: Why not commission a set of good illustrations by an artist with technique and imagination? Consider, for example, the illustrations in the *Scientific American*. They are uniformly good. Certainly, the particular style of these illustrations should not be copied, but our students need illustrations which possess unity of style, artistic excellence, and pedagogical clarity. Properly conceived and executed, they should be less expensive to use than those in this text.

The order of presentation is not unusual. There are 42 chapters, 27 on the descriptive chemistry of the elements and compounds, presented in a stimulating manner. Interspersed among these are the remaining 15 chapters, one each on atomic and molecular structure, the periodic system, formulas and valence, and similar topics; eight chapters on elementary physical chemistry; and two fine chapters on organic chemistry.

The treatment is thorough, as a few examples will illustrate: resonance is clearly explained; astatine, francium, elements 97 to 100 are mentioned several times; ionic strength is defined; the important causes and effects of corrosion are discussed. Short biographical sketches of famous chemists (and others) are presented in appropriate places. There are 115 useful tables; of these, one on organic reactions and 13 on the preparation, properties, and uses of the compounds of the important cations are particularly good.

In summary, this text should be available to all elementary chemistry students as a recommended reference text. And if you are thinking of adopting a new text, be sure to give careful consideration to Sneed, Maynard, and Brasted.

JAY A. YOUNG

King's College
Wilkes-Barre, Pennsylvania

● BIOLOGICAL EFFECTS OF EXTERNAL X AND GAMMA RADIATION. PART I

Edited by *Raymond E. Zirkle*, Professor of Radiobiology, Institute of Radiobiology and Biophysics, University of Chicago. McGraw-Hill Book Co., Inc., New York, 1954. xxvi + 530 pp. Many figs. and tables. 16 × 23.5 cm. $7.25.

This volume is one of the most recent of the National Nuclear Energy Series to be published. It is quite late in appearing and because of this fact it loses some of its effectiveness. To anyone who has worked in, or has been associated with, the Manhattan Engineer District, the monumental effort necessary for editing such a book is quite apparent.

The book in general is an excellent presentation of methods, techniques, and data of a large part of the radiobiology program pursued during World War II at the Metallurgical Laboratory, University of Chicago, and the National Cancer Institute, Bethesda, Maryland. In the very active field of radiobiology much work has been performed and reported in the past eight years. The great majority of chapters in this volume are dated in or around 1946. The references following each of these chapters are also no later than this period and so give no indication of the large volume of work in the field of historical reference. While most of the chapters are restricted in interest and use, two major chapters are outstanding in interest and value: the chapter on Effects of Long-continued Total-body Gamma Irradiation on Mice, Guinea Pigs, and Rabbits. III: Effects on Life Span, Weight, Blood Picture, and Carcinogenesis and the Role of the Intensity of Radiation, and the chapter on Effects of Long-continued Total-body Gamma Irradiation... V. Pathological Observations. These chapters contain not only the work done during the second World War, but have been brought up to date, not only in their content but in the references following each chapter. Both chapters show a wealth of material and might be considered as excellent reference sources. These chapters alone make this volume well worth reading. It is very difficult to understand why the chapter titled Heparinemia (?): An Anticoagulant in the Blood of Dogs with Hemorrhagic Tendency After Total-body Exposure to Roentgen Rays, and that titled Effects of X-rays on Immunity, should have been included as chapters when the first is only one paragraph long and the second is only four paragraphs long and both contain footnotes explaining that they are only abstracts and that the full information can be found elsewhere.

If the reader approaches this book with the view that it contains much of the early basic information in the field of radiobiology, but that it is not the most modern reference on the subject, he will find it most worth-while reading.

FRED A. BRYAN

University of California Medical Center
Los Angeles, California

● NEW SENIOR SCIENCE

George L. Bush and _Will S. Thompson_, Department of Chemistry and General Physical Science, Kent State University, Kent, Ohio. American Book Company, New York, 1954. ix + 642 pp. 16 × 23.5 cm. Illustrated. $4.28.

School textbooks are becoming more and more attractive. "New Senior Science" is extremely so, with its colorful cover picture of an oil well among palmetto palms and Spanish moss. It is profusely illustrated with interesting black and white drawings and instructive photographs.

More than twenty years ago, Ohio made senior science an important and valued part of the high-school curriculum of Cleveland. Today senior science has a variety of names throughout our country. In this present text, the Ohio authors have included the best of the present ideas of what should constitute this upper-grade science so that it may be functional in the lives of young people approaching maturity. They have endeavored to emphasize a large number of major problems that these young people will face, such as wise use of the earth's resources, control of smog, water shortages and water pollution, household equipment, communication and transportation, health problems, and staying alive if an atomic bomb comes. This book should receive consideration from teachers looking for an adequate text for such a course in today's high school.

GRETA OPPE

Ball High School
Galveston, Texas

● THE SCIENCE OF CHEMISTRY

George W. Watt, Professor of Chemistry, and _Lewis F. Hatch_, Associate Professor of Chemistry, The University of Texas. Second edition. McGraw-Hill Book Company, Inc., New York, 1954. x + 546 pp. 193 figs. 19 tables. 15 × 23 cm. $5.50.

The first edition of this text was reviewed in this Journal by Dr. L. Reed Brantley (January, 1950). The new edition is quite similar in arrangement and content but has been shortened by 21 pages. This has been done first by combining and condensing Chapters 1 and 2 into a single chapter, and second by reducing the number of illustrations from 227 to 193. A considerable number of the illustrations are new and there are five excellent

color photographs in the new edition, compared to three in the old. The material covering topics on radioactivity and atomic energy, petroleum, detergents, biological chemistry, medicinals and pharmaceuticals, chemistry and agriculture, and plastics has been partly rewritten to bring it up to date.

In general, the material used is well chosen for the terminal course and there are very few errors. However, this reviewer believes the text would be improved by use of the long form of the periodic table and by pointing out structural relationships in more detail. Chapter 14, Acids, Bases and Salts, leaves the impression that the simple H^+ ion exists in solution. Furthermore, the authors are not consistent in the use of ionic and molecular forms when writing equations. The use of $Na_2{}^+CO_3{}^{--}$ (pages 206, 259, and 266), $Zn^{++}Cl_2{}^-$ (pages 255 and 259), $Mg^{++}Cl_2{}^-$, and $Ca^{++}(OH)_2{}^-$ (page 263) in ionic equations is confusing, to say the least. The commonly used practice of placing the coefficients before the ions and separating each with a + sign is much to be preferred.

Teachers who have used the first edition of this text will welcome the new one, and those who have not will certainly want to examine the second edition. In the opinion of the reviewer this text will continue to hold its place as one of the best for the terminal course.

MORRIS F. STUBBS
NEW MEXICO INSTITUTE OF MINING AND TECHNOLOGY
SOCORRO, NEW MEXICO

● MODERN CHEMICAL PROCESSES. VOLUME III

The Editors of *Industrial and Engineering Chemistry* and technical staffs of cooperating organizations. Reinhold Publishing Corp., New York, 1954. v + 276 pp. Illustrated. 21 × 29 cm. $5.

AN ESTABLISHED feature of *Industrial and Engineering Chemistry* is its lead article, the "Staff-industry collaborative report," in which one of the editors, in collaboration with technical members of some company, prepares an article describing a new plant or process. The 23 articles appearing in 1948 and 1949 appeared as Volume I, the 24 articles of 1950 and 1951 are Volume II, and the 23 articles of 1952 and 1953 have produced Volume III (the *I.E.C.* Lecture Series in November, 1953, replaced the Report).

Of the 23 reports, six are in the inorganic field, while 17 cover organic industries (three are biochemical in nature). Some articles, like "Ammonia at 1000 atmospheres," describe American adaptations of older processes, while others, like "Carboxymethylcellulose," are the first authoritative description of such a process or product. Companies have furnished illustrations, and a large flowsheet always shows the entire process. The articles are not in the order in which they appear in *I.E.C.*, but the reference to the appropriate number and page is given at the end of each article.

These articles, with their interesting and authoritative descriptions, are of value to students and teachers in courses in chemical processes or technology. These three volumes should be readily available to them.

KENNETH A. KOBE
UNIVERSITY OF TEXAS
AUSTIN, TEXAS

● ORGANIC CHEMISTRY

***Reynold C. Fuson* and *H. R. Snyder*, Professors of Chemistry, University of Illinois. Second edition. John Wiley & Sons, Inc., New York, 1954. viii + 544 pp. 15 × 23.5 cm. $6.50.**

THE general pattern of this text is the same as that of the first edition. As stated by the authors in the preface, "... the accelerated introduction to the subject has been retained." The authors have omitted the division of contents and have dropped the chapter on The Synthesis of Carbonyl Compounds and Appendix A on Notes on Nomenclature and Pronunciation. Otherwise, the headings of the chapters and the general content remain the same. The problems have been extended in certain chapters and the suggested readings brought up to date. The chief emphasis in the revision is found in the interpretation of reaction processes in terms of modern concepts.

This text, written expressly for majors in chemistry, assumes a proper background for the subject and presents a panoramic view of organic chemistry as a background for the advanced topics to follow. The incompleteness of discussion at points (particularly the carbohydrates and proteins) leaves much to challenge the teacher in the process of class discussion. The correlative aspects of the subject are left chiefly to the instructor. The omission of the methods of preparation (reasonably justified by the authors) increases the problem for the student.

The emphasis of the authors on functional groups as the seats of reaction, in preference to the emphasis of homologous series, is the unique contribution of the text. This thesis is consistent with the omission of the methods of preparation. The combined presentation of aliphatics and aromatics offers a sound approach and enhances the value of the text for majors in chemistry.

The text is written in a clear, concise style, with consistent usage of good formulas. A remarkable feature is found in the low number of errors present. Although the index is adequate, one finds it wanting at certain places. The printing is excellent and the binding is neat and attractive. This revision has strengthened the contribution of the authors to the field of organic chemistry and the text is to be recommended highly for the specialized type of course for which it is intended.

ROY G. BOSSERT
OHIO WESLEYAN UNIVERSITY
DELAWARE, OHIO

● INDUSTRIAL INORGANIC ANALYSIS

***Roland S. Young*, International Nickel Co. of Canada, Ltd., New York. John Wiley & Sons, Inc., New York, 1953. viii + 368 pp. 12 figs. 7 tables. 15 × 22.5 cm. $5.75.**

THIS book is designed to cover analyses encountered in a "general inorganic laboratory." It is directed to the industrial analytical chemist and to younger chemists being introduced to the methods of routine industrial analysis. The subject matter largely reflects the author's experiences and viewpoint. The preface states: "Over a period of years the writer has accumulated a series of notes on analytical procedure, briefly outlining the theory and the separations necessary in a complex sample, frequently giving certain hints on manipulation which are extremely useful and assessing the value of the method for universal or specialized work."

Analytical procedures for 43 elements are discussed. Over a third of the chapters are five pages or fewer in length. The most complete discussion is given to cobalt, the author's specialty. The book concerns itself primarily with well known and very well tested procedures, often at the expense of some of the newer and better methods. For example, the thiocyanate method is given for iron and no mention is made of the more sensitive and specific 1,10-phenanthroline-type organic ligands. Cupferron is given as the reagent for zirconium; the mandelates, which have been so successful as specific reagents for zirconium, are barely mentioned.

Discussion of principles is rather elementary and should be understood by anyone with a first course in chemical analysis. Often the discussion is limited in scope. For example, for the gravimetric factor of KCl from K_2PtCl_6 the theoretical value is given with no mention of the empirical factor usually recommended or the conditions involved in choice of the appropriate factor. For the separation of sulfur from iron, barium sulfate precipitation is recommended without notation of the serious coprecipitation of iron in this separation.

Notes on procedure are sometimes vague and unduly brief. As

an example, the author recommends that ferric hydroxide be boiled several minutes after precipitation to render it more readily filterable, but he does not caution against the tendency toward sliminess as boiling breaks up the aggregates. Many of the notes on technique, however, are particularly appropriate to industrial laboratories and will be a valuable supplement to the standard procedures already available.

Typographical errors are notably few and binding and format are attractive.

RALPH A. JOHNSON

UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

● CHEMICAL ENGINEERING IN PRACTICE

Edited by *James I. Harper*, Assistant Director, Research and Development Department, Sun Oil Company. Reinhold Publishing Corp., New York, 1954. 140 pp. Illustrated. 13.5 × 19.5 cm. $3.

A ONE-DAY meeting of the Philadelphia-Wilmington section of the American Institute of Chemical Engineers was devoted to an integrated subject: Chemical Engineering in the Process Industries. It was directed toward the younger engineers, to give them a picture of the breadth of work done by chemical engineers in the process industries.

The editor has likened the progress of a research idea to the growth of a child, from infancy to adulthood. The eight chapters representing the succession of steps of progress, are: Process Research, Process Development, Process Engineering, Economic Analysis, Project Engineering, Construction Engineering, Operational Engineering, and Market Research Engineering.

Each chapter tells the young engineer what is done in that particular phase of chemical engineering. Definite examples are given, usually from the work done by the company which the speaker represents. The examples are illustrated with flowsheets, yield curves, and cartoons emphasizing the text material.

Where can this book be used most effectively to show the fields of work into which a chemical engineer can go? A senior seminar course would be ideal; technology or design courses could present this material to show where they fit into the over-all industrial picture; graduate seminars could use it effectively; or it could be used for individual reading. The recent graduate who has entered industry will get a view of the entire employment field from this book. An instructor can use to advantage the examples given in it. It is a worth-while little book that can be used effectively.

KENNETH A. KOBE

UNIVERSITY OF TEXAS
AUSTIN, TEXAS

● AN INTRODUCTION TO ELECTRONIC ABSORPTION SPECTROSCOPY IN ORGANIC CHEMISTRY

A. E. Gillam, Late Senior Lecturer in Chemistry, and Special Lecturer in Chemical Spectroscopy, University of Manchester, and _E. S. Stern_, Chief Research Chemist, J. F. Macfarlan and Company, Ltd., Edinburgh. St. Martin's Press, Inc., New York, 1954. vii + 283 pp. 82 figs. 133 tables. 14.5 × 22 cm. $8.

THE need for a compilation of the applications of ultraviolet and visible absorption spectra to the field of organic chemistry has not been filled by previous publications. The authors of this book have covered this topic in a very clear and concise manner. It is obviously impossible to cover this rapidly expanding field completely in a book of this size; however, the authors have included numerous references making this book an excellent starting point in any literature survey in the field of electronic spectroscopy. It is appropriate that the authors have not presented detailed mathematical interpretations of these phenomena but again have introduced references for those interested in the mathematical aspects of the subject.

A complete description of the absorption of the common functional groups, singly and in combination, is given with many examples cited as illustrations and indexed apart from the subject or author indexes. The use of these absorption spectra for qualitative or quantitative analysis of mixtures or pure compounds is described. The application of electronic absorption spectroscopy to such specialized problems as reaction kinetics, molecular weight determinations, *cis-trans* isomerism, and keto-enol tautomerism also is included.

In describing the use of ultraviolet and visible absorption spectroscopy for structure determination, the authors have considered the several quantitative correlations of effect of substituents and solvent on the absorbancy and/or the wave length of maximum absorption of the chromophoric groups which have been studied.

The form used for graphically presenting absorption spectra in this book, as in the current literature, is not standardized; however, the momentary confusion resulting from this inconsistency is very heavily balanced by the practice or review the student of spectroscopy receives in mentally interconverting these various methods of presentation.

Aside from the more technical aspects of electronic spectroscopy, the authors have included an historical discussion of the instrumentation in this field. This section is not only interesting but will aid in evaluating the data in the earlier literature.

For the organic chemist interested in applying the increasingly important ultraviolet and visible absorption spectroscopy to his field of research, this book is the best available source for an introduction to the field.

ROBERT E. LYLE

UNIVERSITY OF NEW HAMPSHIRE
DURHAM, NEW HAMPSHIRE

● THE PROTEINS: CHEMISTRY, BIOLOGICAL ACTIVITY AND METHODS. VOLUME II, PART A

Edited by *Hans Neurath*, Department of Biochemistry, University of Washington, and *Kenneth Bailey*, Department of Biochemistry, University of Cambridge. Academic Press, Inc., New York, 1954. ix + 661 pp. 77 figs. 16 × 23.5 cm. $14.

IN KEEPING with the procedure followed in Volume I of this treatise on the proteins, the contributors have handled their topics in a comprehensive manner so that the reader will have full information on latest developments in the field and a critical evaluation of current points of view regarding the particular phase of protein chemistry being discussed. Volume I, which dealt with the general properties of proteins, consisted of eleven chapters. In the nine chapters in the present volume (Volume II, Part A) specific groups of proteins are considered from the point of view of their chemical characteristics in relation to their function.

In the first chapter (Chapter 12) R. Markham and J. D. Smith, writing on nucleoproteins and nucleic acids, trace the development of ideas of the structure of these substances from the simple tetranucleotide hypothesis to the present. The separation and analysis of the constituents of nucleoproteins are presented in detail. Full discussion follows on the nature of cytoplasmic and nuclear nucleoproteins, their relationship to the structure of the cell nucleus, and function in the genetic mechanism and protein synthesis. Plant and animal viruses and bacteriophages come in for full treatment.

T. P. Singer and E. B. Kearney in Chapter 13, entitled, "The oxidizing enzymes," restrict themselves to dehydrogenases and oxidases and omit the Fe-containing enzymes. However, the copper-protein enzymes, pyridinoproteins, flavoproteins, and thiaminoprotein enzymes are fully considered with respect to their general properties and their function in tissue metabolism. The respiratory proteins are discussed by F. Haurowitz

and R. L. Hardin in Chapter 14. Attention is directed mainly to hemoglobin and its derivatives, although other respiratory proteins are not omitted.

W. E. Van Heyningen writes Chapter 15 on the action of toxic proteins found in snake venoms and elaborated by certain plants and bacteria. In Chapter 16 the proteins in milk are discussed by T. L. McMeekin and in Chapter 17 the methods of preparation, composition, and properties of egg proteins are presented by R. C. Warner. The late work on seed proteins, that has followed the classical investigations of Osborne, is reviewed by S. Brohult and E. Sandegren (Chapter 18).

The title of Chapter 19 is, "Proteins and protein metabolism in plants." In this chapter F. C. Steward and J. F. Thompson discuss protein synthesis in the growing plant and the relationship between protein-N, carbohydrates, and nonprotein constituents, particularly asparagine and glutamine, during various phases of plant cell activity. The effect of the mineral supply on protein formation in plants is also considered.

The final chapter (Chapter 20) by C. H. Li summarizes in excellent fashion the present knowledge of the protein hormones.

The format of this volume is similar to that of the earlier members of this series. Extensive literature references, many as late as 1953, appear as footnotes. There seem to be few typographical errors, though this reviewer noted some on page 547 and page 642. The reference on page 650 to Kendall's isolation of thyroxin should be 1919, not 1951.

The high quality of the contents of these volumes and their obvious value to anyone interested in the proteins should place them on the shelves of all workers in biochemistry. Unfortunately, this will not happen. Their high cost will be beyond the means of many.

F. A. CAJORI

University of Colorado School of Medicine
Denver, Colorado

● THE COLLECTED PAPERS OF PETER J. W. DEBYE

Interscience Publishers, Inc., New York, 1954. xxi + 700 pp. 21 × 28.5 cm. Illustrated. $9.50.

In 1939 a statue was erected in the town of Maastricht in Holland in honor of its famous son, Peter J. W. Debye. On the occasion of his seventieth birthday on March 24, 1954, Debye's pupils, friends, and publishers have erected a monument more durable than bronze by printing a volume containing a selection of his classical papers. The selection has been made by the author himself, and the wide scope of these fundamentally important papers bears witness of the versatility of one of the greatest physical chemists of our time.

The articles have been arranged in subject groups, *viz.*, X-ray Scattering, Electrolytes, Dipole Moments, Light Scattering, and Miscellaneous. Those originally published in German and Dutch have been translated into English. To place the papers in the proper context and to indicate some of the developments they initiated, a brief survey accompanies each one of the first four groups (authors: R. M. Fuoss, H. Mark, and C. P. Smyth).

GUSTAF ARRHENIUS

Scripps Institution of Oceanography
La Jolla, California

● STRUCTURE AND PROPERTIES OF SOLID SURFACES

Edited by *Robert Gomer* and *Cyril Stanley Smith*. The University of Chicago Press, Chicago, 1953. xvi + 491 pp. 192 figs. 21 tables. 14.5 × 22 cm. $8.50.

This book is the report of a conference organized by the Committee on Solids of the National Research Council. It presents an impressive effort to get at the fundamentals of the theory of surfaces. It gives the work of 19 authors in 14 chapters with the reactions of 45 discussants.

A brief discussion of the problems presented by surfaces by Dr. P. P. Ewald is followed by Dr. Conyers Herring, in which he considers such matters as surface tension, neck growth, surface volume equilibrium, etc. He emphasizes the macroscopic factors that drive a system toward equilibrium rather than the molecular nature of the rate processes themselves. Ewald and Juretsche then discuss the atomic theory of surface energy in fundamental terms. Weyl emphasizes the importance of polarizability of surface ions in determining the wetting of surfaces and, through that, many important properties of the material.

"The adhesion of solids," by Bowden and Tabor, records a variety of interesting experiments. How molecular structure influences crystal structure is interestingly told in a chapter by Wells. Buckley sees little connection between the macroscopic crystal spirals and screw dislocations. He opens up a variety of interesting questions concerning crystal growth.

"Epitoxy" by Seiffert; "Adsorption" by Emmett and by Wheeler, "Catalysis" by Boudart, "Adsorption" by Hill, and "Spinal Catalysis" by Schwabb, Roth, Grintzos, and Mavrakis are all chapters which the surface chemist will profit by and will enjoy.

This book deserves careful study.

HENRY EYRING

University of Utah
Salt Lake City, Utah

● IMIDAZOLE AND ITS DERIVATIVES. PART I

Klaus Hofmann, Professor of Biochemistry, Medical School, University of Pittsburgh. Interscience Publishers, Inc., New York, 1953. xviii + 447 pages. 6 figs. 32 tables. 15.5 × 23.5 cm. Single volume price, $13.50. Subscription price, $12.25.

This monograph is the sixth of a projected series of approximately thirty volumes concerned with various topics in the chemistry of heterocyclic compounds. The present volume is Part I of a two-volume set concerned with the five-membered heterocyclic ring system containing two nitrogen atoms and known as imidazole. Part II is not yet available and it is the intention of the publisher that Part II cover imidazoles condensed with ring systems other than the benzene ring.

The material in the present volume (Part I) is arranged in two main sections. Section 1 contains 324 pages and discusses in eight chapters the following topics: general properties and structure of the imidazoles; the alkyl- and arylimidazoles; the oxy- and hydroxyimidazoles and their sulfur analogues; the halogenoimidazoles; the nitro-, arylazo-, and aminoimidazoles; the imidazolecarboxylic and sulfonic acids; the imidazolines, 2-imidazolidones, 2-imidazolidinethiones, 2-iminoimidazolidines, and imidazolidines; and the benzimidazoles. The first of these chapters is concerned largely with an interpretation of the physical and chemical properties of the imidazole ring in terms of the molecular structure of the ring. The seven chapters which follow are concerned with the methods of synthesis and the properties of the types of compounds indicated. The author has discussed rather carefully and critically the scope and relative value of the various synthetic methods. A thorough command of the imidazole literature is apparent here. The properties and chemical reactions of each group of imidazole derivatives are also adequately discussed. The author has chosen to interpret many of the reactions of imidazoles in terms of resonance structures, transition states, and electron migrations. The thoughtful reader will, of course, be cautious about the acceptance of these interpretations as anything more than useful ideas and will continue to make a careful distinction between the experimental fact that a substance has a particular observable property or undergoes a particular reaction and an explanation of that fact. The mechanistic concepts used in this book have already proven to be

rather useful in aliphatic and aromatic organic chemistry and application of these concepts to heterocyclic chemistry is welcome and should be encouraged. The author has pointed out in his preface, however, that his interpretations are for the most part speculative and "... are given with the aim of stimulating inquiry into the theoretical aspects of imidazole chemistry."

The text is abundantly illustrated with equations using structural formulas. These formulas in most cases have been orientated on the page in such a manner that it is relatively simple to relate particular atoms of the starting products with the corresponding atoms of the final product. The typography of the structural formulas is excellent.

Several groups of naturally occurring substances of considerable physiological or pharmacological importance contain an imidazole or reduced imidazole ring as part of their structure. One major group, the purines, does not come within the scope of this volume, and purines are mentioned only when these are the result of a reaction of a substituted imidazole. Discussion of the growth factor, biotin, has been excluded, apparently for a similar reason. Several pages have been devoted to desthiobiotin, which contains only a substituted imidazolidone ring and is an important degradation product of biotin. Members of another group, the "Jaborandi" alkaloids present in various *Pilocarpus* species, contain an imidazole nucleus and might properly be included in this volume. For unstated reasons, however, the author has chosen to exclude this group. The author has presented rather lengthy discussions totaling 47 pages concerning the important amino acid, histidine, and the related substance, histamine. These discussions are informative and well written but inclusion of such details as isolation, quantitative estimation, and distribution of histidine and histamine in nature seems out of place in a volume primarily devoted otherwise to the organic chemistry of imidazoles.

Section 2 of this monograph consists of 95 pages and is entitled Systematic Survey and Bibliography. This section contains a list of known imidazoles and related compounds within the scope of the book together with melting points, melting points of certain derivatives, and literature references. The survey is reported to be noncritical and covers the years 1919 to 1950. The reader is referred to Beilstein's "Handbuch" for information before this period. This section seems of dubious value to any but those actively engaged in imidazole research. These may find some value in this list of compounds, but similar information is easily, although possibly not quite so rapidly, available from *Chemical Abstracts*.

The 27-page index contains page references only to Section 1 and the general headings of Section 2. Source references in Section 1 have been collected at the end of each chapter and are listed in the order of mention within the chapters. This bibliographical arrangement seems no less convenient than the other common method of placing the references at the bottom of the first page on which they are mentioned and a somewhat neater page appearance has resulted.

This volume fulfills in every respect what should be the twofold aim of such a monograph: to inform and to stimulate further research. The author has made an important and valuable contribution to the chemistry of heterocyclic compounds and to the general field of organic chemistry.

EARL C. SPAETH

UNIVERSITY OF CONNECTICUT
STORRS, CONNECTICUT

● CRYSTAL GROWTH AND DISLOCATIONS

Ajit Ram Verma, **Lecturer in Physics, University of Delhi; I.C.I. Research Fellow, Royal Holloway College, University of London. Academic Press Inc., New York, 1953. xii + 182 pp. 76 figs. 14 × 22 cm. $5.**

A BOOK on "Dislocations in Crystals," by W. T. Read, Jr., was recently reviewed in these pages (J. CHEM. EDUC., **31**, 389 (1954)). The volume now under review deals with the application of dislocation theory to the explanation of phenomena of crystal growth, especially the spiral growth patterns which have been observed on the surfaces of many crystals during the last few years. Many fine photographs of such patterns are included, also good descriptions of the various techniques which have been found useful in studying crystal surfaces.

This book can be recommended to all interested in the present status of theory and experiment in this field.

MAURICE L. HUGGINS

EASTMAN KODAK COMPANY
ROCHESTER, NEW YORK

● THE STORY OF SPICES

John W. Parry. **Chemical Publishing Co., Inc., New York, 1953. vii + 208 pp. 14.5 × 22 cm. $4.50.**

SPICES have been in use by man for so long that a history of the spice trade is almost a history of the world. Unfortunately, Mr. Parry has tried to make it one; his work would have been better had it been more selective. Nevertheless, he has written a fascinating story of the uses of spices (Pliny recommended the use of the smell of garlic to drive away serpents and scorpions), the superstitions concerning them, and the effect of the search for spices and new routes to the spice lands on world history. There is an excellent appendix describing many of the herbs and spices; best of all is the collection of ancient prescriptions using spices to cure everything from heartburn to epilepsy.

G. G. SHOR

SCRIPPS INSTITUTION OF OCEANOGRAPHY
LA JOLLA, CALIFORNIA

● CONCERNING THE NATURE OF THINGS

Sir William Bragg, **Fullerian Professor, Royal Institute, London, England. Reissue. Dover Publications, New York, 1954. xi + 232 pp. 32 plates. 57 figs. 13.5 × 20.5 cm. Cloth, $2.75. Paper, $1.25.**

THIS reprint of lectures given thirty years ago is still full of apt suggestions on the nature of atoms, gases, liquids, and solids. Many demonstrations and vivid teaching analogies are included, particularly for the physicist or physical science survey teacher.

J. A. CAMPBELL

OBERLIN COLLEGE
OBERLIN, OHIO

● GRAPHICS IN ENGINEERING AND SCIENCE

A. S. Levens, **Professor of Engineering Design, University of California, Berkeley, California. John Wiley & Sons, Inc., New York, 1954. viii + 696 pp. 17.5 × 25 cm. $7.**

"GRAPHICS" consists of three sections: (1) fundamentals and applications of orthogonal projection; (2) technical drawing practices; and (3) graphical solutions and computations.

The first section puts more emphasis on orthogonal projection than is usual in a beginning text in engineering drafting. Section three presents elementary mathematics through calculus by graphical methods. Some of the topics covered are functional scales, empirical equations, nomography, graphic statics, graphical calculus (both differentiation and integration), and graphics in research (particularly prosthetic devices).

An ample appendix gives tabulated data, graphical symbols, and drafting room practice.

WILEY — BOOKS

INTRODUCTION TO CHEMISTRY

By R. T. SANDERSON, *State University of Iowa.* A beginning text with more than the usual amount of explanatory material and less emphasis on purely descriptive matter. Chemical principles are thoroughly explained and the author stresses the nature of chemical reactions and the chemical bond. Effective cartoon-type illustrations dramatize basic ideas. 1954. 542 pages. $5.50.

QUANTITATIVE ORGANIC ANALYSIS VIA FUNCTIONAL GROUPS, *Second Edition*

By SIDNEY SIGGIA, *General Aniline and Film Corp.* The new edition has been expanded by almost 40% to cover new developments in this rapidly expanding field. Some of the older material has been dropped and other portions have been changed to take advantage of more effective new procedures. "I am as pleased with this edition of the book as I was with the first edition. I think that Dr. Siggia has done an excellent job."—Professor Philip J. Elving, University of Michigan. 1954. 227 pages. $5.00.

LABORATORY EXPERIMENTS IN PHYSIOLOGICAL CHEMISTRY, *Second Edition*

By ARTHUR K. ANDERSON *and* GORDON H. PRITHAM, *both at the Pennsylvania State University.* Revised in the light of modern laboratory practice, the new edition is a completely up-to-date manual designed to meet the needs of today's students. The scope of the new edition has been broadened to meet the needs of a wider variety of courses. 1954. 179 pages. $2.90.

QUALITATIVE INORGANIC ANALYSIS

A New Physico-Chemical Approach

By G. CHARLOT, *College of Physics and Industrial Chemistry, Paris.* Here is a new system of qualitative inorganic analysis that frees your students of the deadening systematic procedures of the classical methods. Stressing the fundamental properties of matter, it presents them in a novel, useful form and by integrating the physico-chemical approach in the teaching of analysis, offers unique help in instilling a full understanding of chemical processes. 1954. 354 pages. $7.00.

Order your on-approval copies today

METHUEN MONOGRAPHS IN CHEMISTRY AND BIOCHEMISTRY

ACIDS AND BASES

By R. P. BELL, *Oxford University.* 1952. 90 pages. $1.50.

THE THERMODYNAMICS OF THE STEADY STATE

By K. G. DENBIGH, *Cambridge University.* 1952. 103 pages. $1.75.

FLUORINE AND ITS COMPOUNDS

By R. N. HASZELDINE *and* A. G. SHARPE, *both at Cambridge University.* 1952. 152 pages. $1.75.

CHEMISTRY OF THE DEFECT SOLID STATE

By A. L. G. REES, *C.S.I.R.O. Melbourne, Australia.* 1954. 136 pages. $2.00.

SELECTIVE TOXICITY

By ADRIEN ALBERT, *University College, London.* 1951. 228 pages. $1.75.

THE BIOCHEMISTRY OF THE NUCLEIC ACIDS

Second Edition

By J. N. DAVIDSON, *University of Glasgow.* 1953. 163 pages. $2.25.

THE BILE PIGMENTS

By C. H. GRAY, *University of London.* 1953. 142 pages. $1.75.

PROTEIN METABOLISM

By R. B. FISHER, *Oxford University.* 1954. 198 pages. $2.50.

In Press . . .

THE NITROGEN METABOLISM OF MICRO-ORGANISMS

By B. E. FRY, *University of Sheffield.*

THE CHEMISTRY OF LIPIDS OF BIOCHEMICAL SIGNIFICANCE

By J. A. LOVERN, *Food Investigation Organization, Aberdeen, Scotland.*

THE BIOCHEMISTRY OF SEMEN

By T. MANN, *Cambridge University.*

PHOTOSYNTHESIS

By C. P. WHITTINGHAM *and* ROBIN HILL, *both at Cambridge University.*

More news of Wiley publications on page 4

JOHN WILEY & SONS, Inc., 440-4th Ave., New York 16, N. Y.

CLASSIFIED CATALOG OF BOOKS ON DISPLAY AT THE

CHEMICAL EDUCATION Book Exhibit

HOTEL STATLER • NEW YORK • SEPTEMBER 13–17, 1954

HIGH-SCHOOL TEXTS

HOGG, JOHN C., ALLEY, OTIS E., and BICKEL, CHARLES L. *Chemistry: A Course for High Schools.* 3rd Edition 1953 784 pp $3.96 D. Van Nostrand Company, Inc. (#1)

JAFFE, BERNARD. *New World of Chemistry.* Revised Edition 1952 720 pp $4.12 Silver Burdett Company. (#2)

OBOURN, ELLSWORTH S., HEISS, ELWOOD D., and MONTGOMERY, GAYLORD C. *Science in Everyday Life.* 1953 620 pp. $3.80 D. Van Nostrand Company, Inc. (#3)

WEAVER, E. C., and FOSTER, L. S. *Chemistry for Our Times.* 2nd Edition 1954 666 pp $4.12 McGraw-Hill. (#4)

SURVEY

CABLE, EMMET, GETCHELL, ROBERT, and KADESCH, WILLIAM. *The Physical Sciences.* 3rd Edition 1951 544 pp $5.95 Prentice-Hall, Inc. (#5)

CHERONIS, N. D., PARSONS, J. B., and RONNEBERG, C. E. *A Study of the Physical World.* 1950 907 pp $5.75 Houghton Mifflin Company. (#6)

DYER, WALTER S., and MUELLER, MANFRED E. *A Practical Survey of Chemistry.* Revised Edition 1950 564 pp $4.30 Henry Holt and Company. (#7)

GADDUM, L. W., and KNOWLES, H. L. *Our Physical Environment.* 1953 625 pp $5.50 Houghton Mifflin Company. (#8)

HATCHER, W. H. *Introduction to Chemical Science.* 2nd Edition 1949 449 pp $4.50 John Wiley & Sons. (#9)

KRAUSKOPF, K. B. *Fundamentals of Physical Science.* 3rd Edition 1953 694 pp $6.00 McGraw-Hill. (#10)

ROUTH, JOSEPH I. *Fundamentals of Inorganic, Organic and Biological Chemistry.* 3rd Edition 1954 418 pp $4.00 W. B. Saunders Company. (#11)

ROUTH, JOSEPH I. *Laboratory Manual of Chemistry.* 3rd Edition 1954 109 pp $1.75 W. B. Saunders Company. (#12)

WATT, G. W., and HATCH, L. F. *The Science of Chemistry.* 2nd Edition 1954 546 pp $5.50 McGraw-Hill. (#13)

WISTAR, RICHARD. *Man and His Physical Universe: An Integrated Course in Physical Science.* 1953 488 pp $4.75 John Wiley & Sons. (#14)

GENERAL CHEMISTRY

ARNOW, EARLE L., and D ANDREA, MARIE C. *Introduction to Laboratory Chemistry.* 4th Edition 1953 108 pp $1.50 The C. V. Mosby Company. (#15)

BABOR, JOSEPH A. *Basic College Chemistry.* 2nd Edition 1953 766 pp $5.50 Thomas Y. Crowell Company. (#16)

BABOR, JOSEPH A., and KREMER, CHESTER B. *How to Solve Problems in General Chemistry.* 1941 88 pp $1.25 Thomas Y. Crowell Company. (#17)

BABOR, JOSEPH A., and LEHRMAN, ALEXANDER. *General College Chemistry.* 3rd Edition 1951 88 pp $5.50 Thomas Y. Crowell Company. (#18)

BABOR, JOSEPH A. and LEHRMAN, ALEXANDER. *Introductory College Chemistry.* 2nd Edition 1950 814 pp $5.50 Thomas Y. Crowell Company. (#19)

BARKER, J. W., and GLASOE, P. K. *First Year College Chemistry.* 1951 501 pp $5.00 McGraw-Hill. (#20)

BOGERT, L. JEAN. *Fundamentals of Chemistry.* 7th Edition 1953 648 pp $4.50 W. B. Saunders Company. (#21)

BRAY, WILLIAM C., LATIMER, WENDELL M., and POWELL, RICHARD E. *A Course in General Chemistry, Semi-micro-Alternate Form.* 3rd Edition 1950 217 pp $3.50 The Macmillan Company. (#22)

BRESCIA, FRANK. *General College Chemistry.* 1953 581 pp $6.00 The Blakiston Co., Inc. (#23)

BRINKLEY, STUART R. *Principles of General Chemistry.* 4th Edition 1951 703 pp $5.50 The Macmillan Co. (#24)

BRISCOE, H. T. *College Chemistry.* 4th Edition 1951 564 pp $5.25 Houghton Mifflin Company. (#25)

BRISCOE, H. T. *General Chemistry for Colleges.* 4th Edition 1949 773 pp $5.75 Houghton Mifflin Company. (#26)

CAVELTI, JOHN E. *Introductory General Chemistry.* 1952 423 pp $4.50 The Blakiston Co., Inc. (#27)

DAMERELL, V. R. *A Course in College Chemistry.* 1952 587 pp $5.50 The Macmillan Company. (#28)

DEMING, H. G. *Fundamental Chemistry.* 2nd Edition 1947 745 pp $5.00 John Wiley & Sons. (#29)

DEMING, H. G. *General Chemistry.* 6th Edition 1952 656 pp $5.75 John Wiley & Sons. (#30)

DEMING, G. G., and HENDRICKS, B. C. *Introductory College Chemistry.* 2nd Edition 1942 521 pp $4.50 John Wiley & Sons. (#31)

EHRET, WILLIAM F. *Smith's College Chemistry.* 6th Edition 1946 677 pp $5.00 Appleton-Century-Crofts, Inc. (#32)

EHRET, WILLIAM F. *Smith's Introductory College Chemistry.* 3rd Edition 1950 511 pp $4.50 Appleton-Century-Crofts, Inc. (#33)

ELDER, ALBERT L., SCOTT, EWING C., and KANDA, FRANK A. *Textbook of Chemistry.* Revised Edition 1948 758 pp $5.00 Harper & Brothers. (#34)

FOWLES, G. *Lecture Experiments in Chemistry.* 3rd Edition 1947 612 pp $7.00 The Blakiston Co., Inc. (#35)

FRANCIS, CHARLOTTE A., and MORSE, EDNA. *Fundamentals of Chemistry and Application.* 3rd Edition 1950 545 pp $4.50 The Macmillan Company. (#36)

FREY, PAUL. *College Chemistry.* 1952 653 pp $5.95 Prentice-Hall, Inc. (#37)

GAINES, P. C., BINDER, L. C., JR., WOODRIFF, RAY, and JOHANSSON, A. R. *Experiments in General Chemistry.* 1951 190 pp $3.00 The C. V. Mosby Company. (#38)

GAINES, P. C., BINDER, L. C., JR., and WOODRIFF, RAY. *Introduction to Modern Chemistry.* 1951 550 pp $5.00 The C. V. Mosby Company. (#39)

GARRETT, ALFRED B., HASKINS, JOSEPH FREDRIC, and SISLER, HARRY H. *Essentials of Chemistry.* 1951 570 pp $5.00 Ginn and Co. (#40)

GOOSTRAY, STELLA, and SCHWENCK, J. RAE. *Textbook of Chemistry.* 6th Edition 1950 500 pp $4.75 The Macmillan Company. (#41)

The Harvey Lectures, Series 48 (1952–1953) 1954 273 pp $7.50 Academic Press, Inc. (#42)

HOLMES, HARRY N. *General Chemistry.* 5th Edition 1949 808 pp $5.50 The Macmillan Company. (#43)

HOLMES, HARRY N. *Introductory College Chemistry.* 5th Edition 1951 594 pp $5.50 The Macmillan Company. (#44)

HOPKINS, B. S., and BAILAR, J. C. *General Chemistry for Colleges.* 4th Edition 1951 704 pp $6.00 D. C. Heath and Co. (#45)

JONES, W. NORTON. *General Chemistry.* 1954 650 pp Probably $6.00 The Blakiston Co., Inc. (#46)

KING, G. BROOKS, and CALDWELL, WILLIAM E. *The Fundamentals of College Chemistry.* 2nd Edition 1954 594 pp $4.50 American Book Company. (#47)

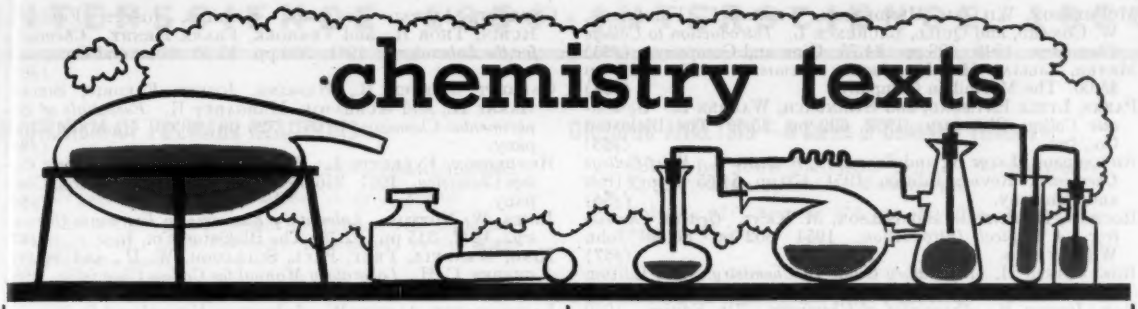
LAUBENGAYER, ALBERT W. *General Chemistry.* 1949 528 pp $2.75 Rinehart & Co., Inc. (#48)

LUDER, WILLIAM F., VERNON, ARTHUR A., and ZUFFANTI, SAVERIO. *General Chemistry.* 1953 595 pp $6.00 W. B. Saunders Company. (#49)

MACK, EDWARD, JR., GARRETT, ALFRED BENJAMIN, HASKINS, JOSEPH FREDRIC, and VERHOEK, FRANK HENRY. *Textbook of Chemistry.* 1949 876 pp $5.50 Ginn and Company. (#50)

MARKHAM, E. C., and SMITH, SHERMAN. *General Chemistry.* 1954 613 pp $6.00 Houghton Mifflin Company. (#51)

MYSELS, KAROL J., and COPELAND, CHARLES S. *Introduction to the Science of Chemistry.* 1952 521 pp $4.75 Ginn and Company. (#52)



Qualitative Analysis and Analytical Chemical Separations

by P. W. West, M. M. Vick & A. L. LeRosen

A practical non-sulfide scheme of separation is presented for the first time in this text. Requiring fewer reagents than most hydrogensulfide schemes and no unusual ones it is possible for students to understand clearly the function of each used. This method allows close correlation between lecture and laboratory work. *1953 223 pp. $3.75*

The Characterization of Organic Compounds

revised edition

by Samuel M. McElvain

This practical text explains the physical and chemical bases for the characterization and identification of organic compounds and includes sixty laboratory exercises. In revision the book includes more procedures for preparation of derivatives, new classes of compounds such as amino acids, and numerous new references to other derivative procedures. *1953 303 pp. $4.50*

College Chemistry— A Systematic Approach

by H. H. Sisler, C. A. VanderWerf & A. W. Davidson

This brief version of the authors' earlier *GENERAL CHEMISTRY—A Systematic Approach* presents a balanced foundation in introductory chemistry with emphasis on the structural basis of matter. The authors have removed much of the historical and detailed descriptive material and have treated the theoretical sections less rigorously. *1953 623 pp. $5.25*

Laboratory Practice of Organic Chemistry

third edition

by G. Ross Robertson

Here is an extensive but informal treatment of the principles underlying laboratory manipulation in organic chemistry. Organized in two major parts, the first consists of theoretical material and the second deals with synthetic experiments and a few examples of elementary qualitative and quantitative analysis. *1954 377 pp. $4.00*

The Biochemistry of Genetics

by J. B. S. Haldane

A summary of published works in a rapidly growing science, this book brings together facts from the whole field of biochemical genetics of unicellular organism, fungi, higher plants, and animals. It deals with the genetically determined, or "inherited" differences between living organisms with emphasis on human metabolic diseases and abnormalities. *Ready early, 1955*

General Chemistry

by L. E. Steiner & J. A. Campbell

This text begins with material not covered in typical high-school courses but which is within the grasp of beginners. It discusses important concepts with a depth to give a firm basis for future work. The fundamental ideas are approached and used repeatedly with different accents while advanced and narrowly applicable material is handled more succinctly. A laboratory manual will be published simultaneously with the text. *Ready January, 1955*

The Macmillan Company

60 FIFTH AVENUE, NEW YORK 11, N. Y.

McPherson, William, Henderson, William E., Fernelius, W. Conard, and Quill, Laurence L. *Introduction to College Chemistry.* 1946 608 pp $4.75 Ginn and Company. (#53)

Meyer, Lillian H. *Introductory Chemistry.* 1951 532 pp $5.00 The Macmillan Company. (#54)

Parks, Lytle Raymond, and Steinbach, Warren H. *Systematic College Chemistry.* 1952 692 pp $5.50 The Blakiston Co., Inc. (#55)

Richardson, Leon B., and Scarlett, Andrew J. *Brief College Chemistry.* Revised Edition 1951 470 pp $4.65 Henry Holt and Company. (#56)

Rochow, Eugene G., and Wilson, M. Kent. *General Chemistry: A Topical Introduction.* 1954 602 pp $6.00 John Wiley & Sons. (#57)

Roe, Joseph H. *Laboratory Guide in Chemistry.* 2nd Edition 1950 216 pp $2.50 The C. V. Mosby Company. (#58)

Roe, Joseph H. *Principles of Chemistry.* 7th Edition 1950 424 pp $3.75 The C. V. Mosby Company. (#59)

Routh, Joseph I. *20th Century Chemistry.* 1953 564 pp $5.75 W. B. Saunders Company. (#60)

Sanderson, R. T. *Introduction to Chemistry.* 1954 542 pp $5.50 John Wiley & Sons. (#61)

Scarlett, Andrew J., and Gomez-Ibanez, Jose. *General College Chemistry.* 5th Edition 1954 645 pp $6.00 Henry Holt and Company. (#62)

Selwood, Pierce W. *General Chemistry.* Revised Edition 1954 657 pp $6.00 Henry Holt and Company. (#63)

Sisler, Harry H., Vanderwerf, Calvin A., and Davidson, Arthur W. *College Chemistry—A Systematic Approach.* 1953 623 pp $5.25 The Macmillan Company. (#64)

Sisler, Harry H., Vanderwerf, Calvin A., and Davidson, Arthur W. *General Chemistry—Systematic Approach.* 1949 870 pp $5.50 The Macmillan Company. (#65)

Sneed, M. Cannon, Maynard, J. Lewis, and Brasted, Robert C. *General College Chemistry.* 2nd Edition 1954 704 pp $6.50 D. Van Nostrand Company, Inc. (#66)

Spicer, W. M., Taylor, W. S., and Clary, J. D. *General Chemistry Problems.* 1943 120 pp $2.25 John Wiley & Sons. (#67)

Sorum, C. H. *How to Solve General Chemistry Problems.* 1952 157 pp $1.85 Prentice-Hall, Inc. (#68)

Timm, J. A. *General Chemistry.* 2nd Edition 1950 764 pp $6.00 McGraw-Hill. (#69)

Young, Leona, and Porter, C. W. *General Chemistry, A First Course.* 3rd Edition 1950 640 pp $5.75 Prentice-Hall, Inc. (#70)

GENERAL CHEMISTRY LABORATORY MANUALS

Babor, Joseph A., and Lehrman, Alexander. *Laboratory Studies in College Chemistry.* 1952 227 pp $2.50 Thomas Y. Crowell Company. (#71)

Babor, Joseph A., and Lehrman, Alexander. *Selected Experiments in College Chemistry.* 1953 125 pp $1.50 Thomas Y. Crowell Company. (#72)

Barker, J. W., and Glasoe, P. K. *Laboratory Manual for First Year College Chemistry.* 1951 186 pp $3.25 McGraw-Hill. (#73)

Belcher, J. E., and Colbert, James Canfield. *Properties and Numerical Relationships of the Common Elements and Compounds.* 5th Edition 1953 366 pp $3.00 Appleton-Century-Crofts, Inc. (#74)

Bogert, L. Jean. *Laboratory Manual of Chemistry* (prepared to accompany Bogert's "Fundamentals of Chemistry"). 196 pp $1.50 W. B. Saunders Company. (#75)

Boyk, S., Gantz, E., and Rice, C. N. *General Chemistry Laboratory Manual.* 1950 243 pp $2.75 Houghton Mifflin Company. (#76)

Briscoe, H. T., Hunt, H., and Whitacre, F. M. *A Laboratory Manual of General Chemistry.* 2nd Edition 1945 326 pp $2.75 Houghton Mifflin Company. (#77)

Burrows, J. Austin, Arthur, Paul, and Smith, Otto M. *Semimicro Laboratory Exercises in General Chemistry.* 2nd Edition 1952 302 pp $3.50 The Macmillan Company. (#78)

Cornog, Jacob. *Semimicro Experiments in General Chemistry.* 1947 217 pp $2.70 Ginn and Company. (#79)

Damerell, V. R. *Laboratory Exercises in College Chemistry.* 1952 124 pp $1.75 The Macmillan Company. (#80)

Eblin, L. P., Clippinger, D. R., and Morton, J. R. *A Laboratory Program for General Chemistry.* 2nd Edition 1954 000 pp. $0.00 Houghton Mifflin Company. (#81)

Elder, Albert L., Scott, Ewing C., Kanda, Frank A., and Burtt, Benjamin P. *Laboratory Manual for General Chemistry.* Revised Edition 1948 244 pp $3.00 Harper & Brothers. (#82)

Fernelius, W. Conard, Garrett, Alfred B., and Quill, Laurence L. *Fundamentals in Chemistry for the Laboratory, Complete Course.* Revised Edition 1950 367 pp $3.00 Ginn and Company. (#83)

Garrett, Alfred Benjamin, Haskins, Joseph Fredric, Rubin, Thor R., and Verhoek, Frank Henry. *Chemistry for the Laboratory.* 1951 356 pp $3.00 Ginn and Company. (#84)

Garrett, Alfred B., Haskins, Joseph Fredric, Sisler, Harry H., and Kurbatov, Margaret H. *Essentials of Experimental Chemistry.* 1951 326 pp $3.00 Ginn and Company. (#85)

Henderson, Everette L. *Experimental Studies in Basic College Chemistry.* 1951 246 pp $2.50 Thomas Y. Crowell Company. (#86)

Jones, W. Norton. *Laboratory Exercises in Inorganic Chemistry.* 1947 315 pp $2.75 The Blakiston Co., Inc. (#87)

King, Wendell, Frey, Paul, Slabaugh, W. H., and Splitgerber, C. H. *Laboratory Manual for College Chemistry.* 1953 252 pp $2.75 Prentice-Hall, Inc. (#88)

Laubengayer, Albert W. *Laboratory Manual and Problems in General Chemistry.* 1949 229 pp $2.75 Rinehart & Co., Inc. (#89)

Markham, E. C., and Reilley, C. N. *Laboratory Manual in General Chemistry.* 1954 000 pp $0.00 Houghton Mifflin Company. (#90)

Markham, E. C., and Smith, Sherman. *General Chemistry Problems.* Form A 1942 190 pp $2.00 Houghton Mifflin Company. (#91)

Markham, E. C., and Smith, Sherman. *General Chemistry Problems.* Form B 1945 190 pp $2.00 Houghton Mifflin Company. (#91–1)

Maynard, J. Lewis, and Taylor, T. I. *Experiments in Inorganic Chemistry.* 1944 550 pp $5.00 D. Van Nostrand Company, Inc. (#92)

Meyer, Lillian H. *Laboratory Manual to Introductory Chemistry.* 1951 114 pp $1.75 The Macmillan Company. (#93)

Morse, Stanley W. *Chemical Symbolism and Calculations.* 2nd Edition Revised and Enlarged 1953 141 pp $2.00 The National Press. (#94)

Neckhamkin, Howard. *Laboratory Problems in General Chemistry.* 1953 271 pp $2.50 Thomas Y. Crowell Company. (#95)

Neckers, J. W., Abbott, T. W., and Van Lente, K. A. *Experimental General Chemistry.* 2nd Edition 1949 307 pp $2.50 Thomas Y. Crowell Company. (#96)

Richardson, Leon B., and Scarlett, Andrew J. *Laboratory Manual for Brief College Chemistry.* Revised Edition 1951 221 pp $2.00 Henry Holt and Company. (#97)

Scarlett, Andrew J. *Laboratory Manual for General College Chemistry.* 1954 256 pp $2.75 Henry Holt and Company. (#98)

Selwood, Pierce W. *Experiments in General Chemistry.* Revised Edition 1954 288 pp $2.75 Henry Holt and Company. (#99)

Silverman, Alexander. *Selective Experiments in General Chemistry.* Revised Edition 1942 310 pp $4.00 D. Van Nostrand Company, Inc. (#100)

Sisler, Harry H., and Stewart, Jay J. *Systematic Laboratory Courses in General Chemistry.* 1950 395 pp $3.00 The Macmillan Company. (#101)

Sneed, M. Cannon, and Maynard, J. Lewis. *General Inorganic Chemistry.* 1942 1166 pp $5.75 D. Van Nostrand Company, Inc. (#102)

Stone, H. W., and McCullough, J. D. *Experiments, Theory and Problems of General Chemistry.* 1953 349 pp $6.00 McGraw-Hill. (#103)

Timm, J. A., and Neal, R. E. *Laboratory Exercises in General Chemistry.* 1948 231 pp $3.25 McGraw-Hill. (#104)

Watt, G. W. *Laboratory Experiments in General Chemistry and Qualitative Analysis.* 2nd Edition 1951 227 pp $3.50 McGraw-Hill. (#105)

Watt, G. W., and Hatch, L. F. *Chemical Laboratory Experiments.* 1949 185 pp $3.00 McGraw-Hill. (#106)

Watt, G. W., and Morgan, L. O. *Laboratory Experiments in General Chemistry and Semimicro Qualitative Analysis.* 1953 228 pp $3.50 McGraw-Hill. (#107)

Young, Leona, and Porter, C. W. *Laboratory Manual,* 3rd Edition 1950 288 pp $2.75 Prentice-Hall, Inc. (#108)

INORGANIC

Audrieth, L. F. *Inorganic Syntheses.* Volume III 1950 230 pp $5.00 McGraw-Hill. (#109)

Audrieth, L. F., and Ogg, Betty Ackerson. *The Chemistry of Hydrazine.* 1951 244 pp $7.00 John Wiley & Sons. (#110)

Bailar, J. *Inorganic Syntheses.* Volume IV 1953 218 pp $5.00 McGraw-Hill. (#111)

Barnett, E. de B., and Wilson, C. L. *Advanced Textbook on Inorganic Chemistry.* 1953 512 pp $7.00 Longmans. (#112)

Booth, H. S. *Inorganic Syntheses.* Volume I. 1939 350 pp $5.00 McGraw-Hill. (#113)

INTERSCIENCE · 1954 · INTERSCIENCE · 1954

MECHANISM OF POLYMER REACTIONS

By G. M. Burnett, *University of Birmingham, England.*

509 pages, 86 illus., 110 tables. Approx. $10.00

This is the second version of Volume III, replacing Mark-Raff, "High Polymeric Reactions," in the High Polymers series.

CELLULOSE AND CELLULOSE DERIVATIVES

2nd Revised and Augmented Edition, in three parts.

Edited by Emil Ott, Harold M. Spurlin, and Mildred W. Grafflin, *Hercules Powder Company.*

PART I: 517 pages, 139 illus., 11 tables. Approx. $11.00

PART II: Approx. 563 pages., 118 illus., 54 tables. Approx. $11.00

PART III: Approx. 480 pages, 127 illus., 41 tables. (With Indexes of Parts I-III). Approx. $11.00. Ready in February 1955.

This is Volume V of "High Polymers."

EMULSION POLYMERIZATION

By Frank A. Bovey, *Minnesota Mining and Manufacturing Co.*, I. M. Kolthoff, *University of Minnesota*, Avrom Medalia, *Boston University*, and Edward J. Meehan, *University of Minnesota.*

Approx. 456 pages, 104 illus., 79 tables. Approx. $10.00

This is Volume IX of "High Polymers."

THE RHEOLOGY OF BUILDING AND ROADMAKING MATERIALS

Edited by M. Reiner.

Approx. 550 pages. Approx. $12.00

This is Volume VII of "Deformation and Flow."

SYMPOSIUM ON MACROMOLECULES

International Union of Pure and Applied Chemistry

Stockholm-Uppsala, July 29–August 7, 1953

Constitutes Journal of Polymer Science, Volume XII, January 1954.

647 pages. $15.00

FIBER MICROSCOPY

A Textbook and Laboratory Manual

By A. N. J. Heyn, *Clemson Agricultural College.*

396 pages, 37 illus., 6 tables. $5.50

(Interscience Manual No. 2)

ORGANIC ANALYSIS—A Series of Collective Volumes

Edited by John Mitchell, Jr., I. M. Kolthoff, E. S. Proskauer, and A. Weissberger.

Volume II: Approx. 358 pp., 60 illus., 65 tables. Approx. $8.50

DETERGENCY EVALUATION AND TESTING

By Jay C. Harris, *Monsanto Chemical Company Daylon, Ohio*

208 pages, 26 illus., 15 tables. $3.75

(Interscience Manual No. 4)

HANDBOOK OF COSMETIC MATERIALS—Their Properties, Uses, and Toxic and Dermatologic Actions

By Leon Greenberg and David Lester, *Laboratory of Applied Physiology, Yale University.*

With a chapter on the skin by Howard W. Haggard.

467 pages. $12.50

THE PRACTICE OF MODERN PERFUMERY

By Paul Jellinek. Translated and revised by A. J. Krajkeman.

224 pages. $4.75

THE CHEMISTRY AND CHEMICAL TECHNOLOGY OF COTTON

Edited by Kyle Ward, Jr., *The Institute of Paper Chemistry.*

Approx. 736 pages, 86 illus., 78 tables. Approx. $17.00

THE PHYSICAL CHEMISTRY OF DYEING

2nd Edition

By T. Vickerstaff.

509 pages, 137 illus. $7.50

DICTIONARY OF DAIRYING

By J. G. Davis.

766 pages, 185 illus. Approx. $10.00

PHYSICAL PROPERTIES OF SOLID MATERIALS

By C. Zwikker, *National Aeronautical Research Institute, Amsterdam.*

308 pages, 332 illus. $8.75

PROGRESS IN METAL PHYSICS, Volume V

Edited by Bruce Chalmers, *University of Toronto.*

317 pages, 236 illus., 27 tables. $9.50

INTERSCIENCE PUBLISHERS, INC.

250 Fifth Avenue, New York 1, N. Y.

BOOTH, H. S., and MARTIN, D. R. *Boron Trifluoride and Its Derivatives.* 1949 296 pp $9.00 John Wiley & Sons. (#114)

DODD, R. E., and ROBINSON, P. L. *Experimental Inorganic Chemistry* (A Guide to Laboratory Practice). 1953 424 pp $6.50 Elsevier Press. (#115)

EMELEUS, H. J., and ANDERSON, J. S. *Modern Aspects of Inorganic Chemistry.* 2nd Edition 1952 557 pp $6.75 D. Van Nostrand Company, Inc. (#116)

GMELINS. *Handbuch der Anorganischen Chemie.* 8th Edition 1954 Supplement Volume System No. 13 (Boron) 253 pp 28 graphs $33.60 Walter J. Johnson, Inc. (#116-1)

GMELINS. *Handbuch der Anorganischen Chemie.* 8th Edition 1954 System No. 62 (Gold) Part 2 306 pp 20 graphs $40.32 Walter J. Johnson, Inc. (#116-2)

GMELINS. *Handbuch der Anorganischen Chemie.* 8th Edition 1954 System No. 62 (Gold) Part 3 558 pp 210 graphs $74.88 Walter J. Johnson, Inc. (#116-3)

GMELINS. *Handbuch der Anorganischen Chemie.* 8th Edition 1953 System No. 10 (Selenium) Part A, Section 3 184 pp 158 graphs $26.64 Walter J. Johnson, Inc. (#116-4)

GMELINS. *Handbuch der Anorganischen Chemie.* 8th Edition 1952 System No. 9 (Sulfur) Part A, Section 2: Occurrence. Technology of sulfur and sulfur compounds. 450 pp 76 graphs $58.56 Water J. Johnson, Inc. (#116-5)

GMELINS. *Handbuch der Anorganischen Chemie.* 8th Edition 1953 System No. 9 (Sulfur) Part A, Section 3: The Element Sulfur. Physical and chemical properties. 252 pp 54 graphs $34.08 Walter J. Johnson, Inc. (#116-6)

GMELINS. *Handbuch der Anorganischen Chemie.* 8th Edition 1953 System No. 9 (Sulfur) Part B, Section 1: Compounds of Sulfur with Hydrogen and Oxygen. 372 pp 75 graphs $48.96 Walter J. Johnson, Inc. (#116-7)

GMELINS. *Handbuch der Anorganischen Chemie.* 8th Edition 1951 System No. 41 (Titanium) 481 pp 100 graphs $64.32 Walter J. Johnson, Inc. (#116-8)

HAZELDINE, R. N., and SHARPE, A. G. *Fluorine and Its Compounds.* 1951 153 pp $1.75 John Wiley & Sons. (#117)

HILDEBRAND, JOEL H., and POWELL, RICHARD E. *Principles of Chemistry.* 6th Edition 1952 444 pp $4.50 The Macmillan Company. (#118)

HILDEBRAND, JOEL, and POWELL, RICHARD E. *Principles of Chemistry.* 6th Edition with Latimer-Hildebrand Reference Book of Inorganic Chemistry 3rd Edition 1952 625 pp $7.50 The Macmillan Company. (#119)

HILLEBRAND, W. F., LUNDELL, G. E. F., BRIGHT, H. A., and HOFFMAN, J. I. *Applied Inorganic Analysis: With Special Reference to the Analysis of Metals, Minerals and Rocks.* 2nd Edition 1034 pp $15.00 John Wiley & Sons. (#120)

HUCKEL, W. *Structural Chemistry of Inorganic Chemistry.* Volume I 1950 438 pp $10.00 Elsevier Press. (#121)

HUCKEL, W. *Structural Chemistry of Inorganic Chemistry.* Volume II 1952 656 pp $14.50 Elsevier Press. (#122)

HURD, DALLAS T. *An Introduction to the Chemistry of the Hydrides.* 1952 231 pp $6.50 John Wiley & Sons. (#123)

JONES, W. NORTON. *Inorganic Chemistry.* 1947 866 pp $5.00 The Blakiston Co., Inc. (#124)

KOBE, KENNETH A. *Inorganic Process Industries.* 1948 371 pp $6.00 The Macmillan Company. (#125)

KOLTHOFF, I. M. *Acid-Base Indicators.* 1937 514 pp $10.00 The Macmillan Company. (#126)

LATIMER, WENDELL. *Oxidation Potentials.* 2nd Edition 1952 392 pp $7.50 Prentice-Hall, Inc. (#127)

LATIMER, WENDALL M., and HILDEBRAND, JOEL H. *Reference Book of Inorganic Chemistry.* 3rd Edition 1951 625 pp $5.00 The Macmillan Company. (#128)

MARTELL, ARTHUR, and CALVIN, MELVIN. *Chemistry of the Metal Chelate Compounds.* 1952 613 pages $10.00 Prentice-Hall, Inc. (#129)

MOELLER, THERALD. *Inoryanic Chemistry: An Advanced Textbook.* 1952 966 pp $10.00 John Wiley & Sons. (#130)

PALMER, W. G. *Experimental Inorganic Chemistry.* 1954 577 pp $9.00 Cambridge University Press. (#131)

SEIDELL, ATHERTON. *Supplement to Solubilities of Inorganic and Organic Compounds.* Volume III 1952 1255 pp $15.00 D. Van Nostrand Company, Inc. (#132)

SNEED, M. CANNON, MAYNARD, J. LEWIS, and BRASTED, ROBERT C. *Comprehensive Inorganic Chemistry.* (Volume I. Principles of Atomic and Molecular Structure—Theoretical and Applied Nuclear Chemistry—The Actinide Series.) 1953 264 pp $5.00 D. Van Nostrand Company, Inc. (#133)

SNEED, M. CANNON, MAYNARD, J. LEWIS, and BRASTED, ROBERT C. *Comprehensive Inorganic Chemistry* (Volume II—Copper, Silver and Gold). 1954 256 pp $5.00 D. Van Nostrand Company, Inc. (#134)

SNEED, M. CANNON, MAYNARD, J. LEWIS, and BRASTED, ROBERT C. *Comprehensive Inorganic Chemistry.* Volume III 1954 Approx 250 pp About $5.00 D. Van Nostrand Company, Inc. (#135)

WALTON, HAROLD. *Inorganic Preparations.* 1948 183 pp $3.25 Prentice-Hall, Inc. (#136)

YOUNG, ROLAND S. *Industrial Inorganic Analysis.* 1953 368 pp $5.75 John Wiley & Sons. (#137)

ANALYTICAL

General

Analytica Chimica Acta. Monthly journal Vol X Issues 6 and 7 1954 Subscription price per volume $12.00 Elsevier. (#138)

AUDRIETH, L. F., and KLEINBERG, JACOB. *Non-Aqueous Solvents.* 1953 284 pp $6.75 John Wiley & Sons. (#139)

BOLTZ, DAVID. *Selected Topics in Modern Instrumental Analysis.* 1952 490 pp $6.00 Prentice-Hall, Inc. (#140)

BRIMLEY, ROBERT C., and BARRETT, FREDERICK. *Practical Chromatography.* 1953 128 pages $5.00 Reinhold Publishing Corp. (#141)

COMMITTEE ON ANALYTICAL REAGENTS. *Reagent Chemicals.* 1950 402 pp and 41 pp supplement $5.00 American Chemical Society. (#142)

DUVAL, CLEMENT. *Inorganic Thermogravimetric Analysis.* 1953 $11.00 532 pp Elsevier Press. (#143)

FEIGL, FRITZ. *Spot Tests.* (Volume I—Inorganic Applications) 1954 530 pp $6.50 Elsevier Press. (#144)

FEIGL, FRITZ. *Spot Tests.* (Volume II—Organic Applications) 1954 452 pp $6.25 Elsevier Press. (#145)

GIBB, T. R. P. *Optical Methods of Chemical Analysis.* 1942 391 pp $7.50 McGraw-Hill. (#146)

GORDY, WALTER, SMITH, WILLIAM V., and TRAMBARULO, RALPH. *Microwave Spectroscopy.* 1953 446 pp $8.75 John Wiley & Sons. (#147)

HAMILTON, L. F., and SIMPSON, S. F. *Calculations of Analytical Chemistry.* 5th Edition 1954 395 pp $5.00 McGraw-Hill. (#148)

HARLEY, JOHN H., and WIBERLEY, STEPHEN E. *Instrumental Analysis.* 1954 440 pp $6.50 John Wiley & Sons. (#149)

HARRISON, GEORGE, LORD, R. C., and LOOFBOUROW, J. R. *Practical Spectroscopy.* 1948 605 pages $6.50 Prentice-Hall, Inc. (#150)

HORSLEY, L. H., ET AL. *Azeotropic Data.* 1952 329 pp $4.00 American Chemical Society. (#151)

JACOBS, MORRIS B. *Chemical Analysis.* (Volume I—The Analytical Chemistry of Industrial Poisons, Hazards, and Solvents) 2nd Edition Revised and enlarged 1949 806 pp $14.75 Interscience Publishers, Inc. (#152)

JACOBS, MORRIS B., and SCHEFLAN, LEOPOLD. *Chemical Analysis Series.* (Volume VII—Chemical Analysis of Industrial Solvents) 1953 523 pp $12.00 Interscience Publishers, Inc. (#153)

KIRK, PAUL L. *Crime Investigation.* 1953 806 pp $12.50 Text edition $10.00 Interscience Publishers, Inc. (#154)

KLUG, HAROLD P., and ALEXANDER, LEROY E. *X-Ray Diffraction Procedures for Polycrystalline and Amorphous Materials.* 1954 716 pp $15.00 John Wiley & Sons. (#155)

LEDERER, EDG. *Chromatography* (A Review of Principles and Applications) 1953 460 pp $9.25 Elsevier Press. (#156)

LINGANE, JAMES J. *Electroanalytical Chemistry.* 1953 458 pp $8.50 Interscience Publishers, Inc. (#157)

MELLON, M. G. *Analytical Absorption Spectroscopy.* 1950 618 pp $10.00 John Wiley & Sons. (#158)

MITCHELL, JOHN, JR., and SMITH, DONALD MILTON. *Chemical Analysis Series.* (Volume V—Aquametry) 1948 456 pp $10.50 Interscience Publishers, Inc. (#159)

MITCHELL, JR., JOHN, KOLTHOFF, I. M., PROSKAUER, E. S., and WEISSBERGER, A. *Organic Analysis.* Volume I 1953 481 pp $8.50 Interscience Publishers, Inc. (#160)

MITCHELL, JR. JOHN, KOLTHOFF, E. S., and WEISSBERGER, A. *Organic Analysis.* Volume II 1954 Approx 332 pp Approx $8.50 Interscience Publishers, Inc. (#160-1)

MULLER, OTTO H. *The Polarographic Method of Analysis.* 2nd Edition 1951 209 pp $3.50 Chemical Education Publishing Co. (#161)

NACHTRIEB, N. H. *Principles and Practice of Spectrochemical Analysis.* 1950 324 pp $6.00 McGraw-Hill. (#162)

POLLARD, F. H., and MCOMIE, J. F. W. *Chromatographic Methods of Inorganic Analysis.* 1953 192 pp Academic Press, Inc. (#163)

RADLEY, J. A., and GRANT, JULIUS. *Fluorescence Analysis in Ultra Violet Light.* 5th Edition 1954 560 pp $12.00 D. Van Nostrand Company, Inc. (#164)

RANDALL, HARRISON M., FOWLER, RICHARD G., FUSON, NELSON, and DANGL, ROBERT. *Infrared Determination of Organic Structure.* 1949 237 pp $12.75 D. Van Nostrand Company, Inc. (#165)

REINER, MIRIAM. *Standard Methods of Clinical Chemistry* (American Association of Clinical Chemists) Volume I 1953 142 pp $4.50 Academic Press, Inc. (#166)

. . . And Reference Works

COMPREHENSIVE INORGANIC CHEMISTRY

Edited by M. Cannon Sneed, J. Lewis Maynard and Robert C. Brasted

VOLUME I: Principles of Atomic and Molecular Structure by William N. Lipscomb; **Theoretical and Applied Nuclear Chemistry** by Paul R. O'Connor; **The Actinide Series** by Glenn T. Seaborg

The first Volume builds a firm foundation for the entire series by furnishing a well rounded, concise account of atomic and molecular structure. The chapter on nuclear chemistry covers both the theory and application of nuclear reactions, to give a working knowledge of this important research implement. The chapter on the actinide series reviews the present state of chemical knowledge of the actinide series as a whole, and the elements actinium, thorium, protactinium, uranium, neptunium, plutonium, americium, curium, berkelium and californium.

232 Pages, $5.00

VOLUME II: Copper, Silver and Gold by James W. Laist

This book realizes fully the great major objective of the entire Series—to present the information most useful and most necessary in its particular field. For the metals, copper, silver and gold the most important information, besides a thorough coverage of the chemistry of all the significant compounds, are the processes for recovering these metals from their ores, and the composition and properties of the alloys commercially valuable today. Even a brief glance at the book's table of Contents will reveal how thoroughly it achieves this broad scope, within the desirable limits of convenient size and moderate cost.

242 Pages, $5.00

VOLUME III: The Halogens by Robert C. Brasted

This systematic account of the halogen elements (fluorine, chlorine, bromine, iodine and astatine) and their compounds is fully up-to-date in every respect. Properties and reactions are explained in light of present-day concepts of structure and mechanism. Industrial processes, methods of production and technical applications reflect the newest developments and the latest advances. Hundreds of references make this book a most direct guide to the chemistry and technology of the halogen elements and their compounds.

284 Pages, $5.00

COLORIMETRIC METHODS OF ANALYSIS

VOLUME IV: Organic Determinations II (Final Volume)

By Foster Dee Snell and Cornelia T. Snell

The thorough coverage of the colorimetric methods of analysis, which was achieved in the first three volumes of this Set, for the inorganic compounds and many of the organic compounds, is extended in this final volume to the remaining types of organic compounds. They comprise Nitro Compounds, Amines and Amides, Amino Acids, Proteins, Azo Compounds, Nitrogen-Containing Cyclic Compounds, Urea and Related Compounds, Organic Compounds with Inorganic Radicals, Sterols, Hormones, Alkaloids, Enzymes, Antibiotics, Hemoglobin and Related Compounds, Natural Pigments. This book is organized by the same plan as the other volumes, giving for each method of determination for each substance, the details of sampling, the step-by-step outline of procedure, the calculations, and all the variations of the method to be followed for special products.

542 Pages, $12.50

VOL. I	**Principles, Apparatus and pH**	239 Pages, $ 6.00
VOL. II	**Inorganic Determinations**	950 Pages, $15.00
VOL. III	**Organic Determinations—I**	576 Pages, $12.50

REAGENT CHEMICALS AND STANDARDS Second Edition

By Joseph Rosin

This book gives the most direct and practical methods for testing more than five hundred important chemicals. For each there are full working directions both for the quantitative estimation of impurities, and for the quantitative determination of the active substance in the reagent. There are also detailed methods for the preparation and standardization of a wide range of volumetric solutions. There are complete tables of equivalents for the quick calculation of the results. There is information about pH determination, pH indicators, buffer solutions, and many other important and useful topics, all arranged most conveniently for quick reference.

To be published in the Fall of 1954

These books and many other important VAN NOSTRAND works in chemical science are on display at the Chemical Education Book Exhibit. All VAN NOSTRAND books are available on approval.

250 Fourth Ave., New York 3, N. Y. *Publishers Since 1848*

SAMUELSON, OLOF. *Ion Exchangers in Analytical Chemistry.* 1953 291 pp $6.50 John Wiley & Sons. (#167)

SANDELL, E. B. *Chemical Analysis Series.* (Volume III—Colorimetric Determination of Traces of Metals) 2nd Edition revised and enlarged 1950 693 pp $10.50 Interscience Publishers, Inc. (#168)

SAWYER, RALPH. *Experimental Spectroscopy.* 2nd Edition 1951 384 pp $5.50 Prentice-Hall, Inc. (#169)

SCHAEFFER, HAROLD F. *Microscopy for Chemists.* 1953 264 pp $4.50 D. Van Nostrand Company, Inc. (#170)

SMITH, ORSINO C. *Inorganic Chromatography* 1953 146 pp $5.00 D. Van Nostrand Company, Inc. (#171)

SNELL, FOSTER D., and SNELL, CORNELIA T. *Colorimetric Methods of Analysis.* (Volume I—Principles, Apparatus, and pH) 3rd Edition 1948 239 pp $6.00 D. Van Nostrand Company, Inc. (#172)

SNELL, FOSTER D., and SNELL, CORNELIA T. *Colorimetric Methods of Analysis.* (Volume II—Inorganic Determinations) 3rd Edition 1949 916 pp $12.50 D. Van Nostrand Company, Inc. (#173)

SNELL, FOSTER D., and SNELL, CORNELIA T. *Colorimetric Methods of Analysis.* (Volume III—Organic Compounds I) 1953 576 pp $12.50 D. Van Nostrand Company, Inc. (#174)

SNELL, FOSTER G., and SNELL, CORNELIA T. *Colorimetric Methods of Analysis.* (Volume IV—Organic Compounds II) 1954 About $12.50 About 576 pp D. Van Nostrand Company, Inc. (#175)

STRANDBERG, M. W. P. *Microwave Spectroscopy.* 1954 140 pp $2.50 John Wiley & Sons. (#176)

SWIFT, ERNEST. *A System of Chemical Analysis.* 1939 589 pp $6.00 Prentice-Hall, Inc. (#177)

WILLARD, HOBART H., MERRITT, LYNNE L., JR., and DEAN, JOHN A. *Instrumental Methods of Analysis.* 2nd Edition 1951 344 pp $5.50 D. Van Nostrand Company, Inc. (#178)

ZECHMEISTER, L. *Progress of Chromatography.* 1951 368 pp $8.00 John Wiley & Sons. (#179)

QUALITATIVE

ARTHUR, P., and SMITH, O. M. *Semimicro Qualitative Analysis.* 3rd Edition 1952 285 pp $4.25 McGraw-Hill (#180)

BABOR, JOSEPH A., and MACALPINE, KENNETH W. *How to Solve Problems in Qualitative Analysis.* 1943 93 pp $1.25 Thomas Y. Crowell Company. (#181)

BARBER, HERVEY HARVEY, and TAYLOR, T. IVAN. *Semimicro Qualitative Analysis.* Revised Edition 1953 404 pp $4.50 Harper & Brothers. (#182)

BELCHER, J. E., and WILLIAMS, G. Y. *A Course in Qualitative Analysis.* 1938 265 pp $4.00 Houghton Mifflin Company. (#183)

CALDWELL, WILLIAM E., and KING, G. BROOKS. *A Brief Course in Semimicro Qualitative Analysis.* 1953 163 pages $2.10 American Book Company. (#184)

CHARLOT and MURRAY. *Qualitative Inorganic Analysis.* 1954 500 pp $7.50 John Wiley & Sons. (#185)

CORNOG, JACOB. *Semimicro Qualitative Analysis.* 1938 265 pp $3.75 Houghton Mifflin Company. (#186)

CURTMAN, LOUIS J. *Introduction to Semimicro Qualitative Analysis.* 2nd Edition 1950 391 pp $4.00 The Macmillan Company. (#187)

ENGELDER, C. J. *Fundamentals of Semi-micro Qualitative Analysis.* 1947 385 pp $4.00 John Wiley & Sons. (#188)

EVANS, WILLIAM L., DAY, JESSE E., and GARRETT, ALFRED B. *An Elementary Course in Qualitative Analysis.* 1943 240 pp $2.90 Ginn and Company (#189)

EVANS, WILLIAM L., GARRETT, ALFRED B., and SISLER, HARRY H. *Semimicro Qualitative Analysis.* Revised Edition 1951 240 pp $3.00 Ginn and Company. (#190)

FALES, HAROLD A., and KENNY, FREDERIC. *Inorganic Qualitative Analysis.* 3rd Edition 1953 284 pp $3.00 Appleton-Century-Crofts, Inc. (#191)

GRIFFIN, CARROLL W., and PLUNKETT, MARY ALYS. *Inorganic Semimicro Qualitative Analysis.* 1951 299 pp $5.00 The Blakiston Co., Inc. (#192)

HARTSUCH, BRUCE E. *A Simplified Course in Qualitative Analysis.* 1949 192 pp $3.00 D. Van Nostrand Company, Inc. (#193)

HEISIG, G. B. *Theory and Practice of Semimicro Qualitative Analysis.* 2nd Edition 1950 356 pp $4.00 W. B. Saunders Company. (#194)

HOGNESS, THORFIN R., and JOHNSON, WARREN C. *Ionic Equilibrium as Applied to Qualitative Analysis.* 3rd Edition 1954 381 pp $3.90 Henry Holt and Company. (#195)

HOGNESS, THORFIN R., and JOHNSON, WARREN C. *Qualitative Analysis and Chemical Equilibrium.* 4th Edition 1954 621 pp $5.00 Henry Holt and Company. (#196)

KELSEY, ERWIN B., and DIETRICH, HAROLD G. *Fundamentals of Semimicro Qualitative Analysis.* 2nd Edition 1951 328 pp $4.50 The Macmillan Company. (#197)

MCALPINE, ROY K., and SOULE, BYRON A. *Fundamentals of Qualitative Chemical Analysis.* 3rd Edition 1949 370 pp $3.75 D. Van Nostrand Company, Inc. (#198)

MCALPINE, ROY K., and SOULE, BYRON A. *Prescott and Johnson's Qualitative Chemical Analysis.* 2nd Edition 1933 707 pp $6.75 D. Van Nostrand Company, Inc. (#199)

MELDRUM, WILLIAM BUELL, and DAGGETT, ALBERT FREDERICK. *A Textbook of Qualitative Analysis.* 1951 442 pages $4.50 American Book Company. (#200)

OELKE, WILLIAM C. *Semimicro Qualitative Analysis.* 1950 386 pp $4.00 D. C. Heath and Co. (#201)

OESPER, RALPH E. (Original French text by Charlot, Bezier and Gauguin) *Rapid Detection of Cations.* 1st American Edition 1954 92 pp $3.00 Chemical Publishing Co., Inc. (#202)

SMITH, ORSINO C. *Identification and Qualitative Chemical Analysis of Minerals.* 2nd Edition 1953 420 pp $7.50 D. Van Nostrand Company, Inc. (#203)

SORUM, C. H. *Introduction to Semimicro Qualitative Analysis.* 2nd Edition 1953 192 pp $2.65 Prentice-Hall, Inc. (#204)

STOCK, J T, and HEATH P. *Small-Scale Inorganic Qualitative Analysis.* 1954 96 pp $2.50 Chemical Publishing Co., Inc. (#205)

VOGEL, ARTHUR I. *Textbook of Macro and Semimicro Qualitative and Inorganic Analysis.* 4th Edition 1954 680 pp $4.50 Longmans. (#206)

WEST, PHILIP W., VICK, MAURICE M., and LE ROSEN, ARTHUR L. *Qualitative Analysis and Analytical Chemical Separations.* 1953 223 pp $3.75 The Macmillan Company. (#207)

WIIG, EDWIN O., LINE, WILLARD R., and FLAGG, JOHN F. *Semimicro Qualitative Analysis.* 1954 240 pp $3.25 D. Van Nostrand Company, Inc. (#208)

QUANTITATIVE

ARENSON, SAUL B. *How to Solve Problems in Quantitative Analysis.* 1942 89 pp $1.25 Thomas Y. Crowell Company (#209)

CLARK, GEORGE L., NASH, LEONARD K., and FISCHER, ROBERT B. *Quantitative Chemical Analysis.* 1949 448 pp $4.50 W. B. Saunders Company. (#210)

CLIPPINGER, DONALD R. *Manual of Quantitative Analysis.* 1948 341 pp $3.50 Ginn and Company. (#211)

DIEHL, HARVEY, and SMITH, G. FREDERICK. *Quantitative Analysis: Elementary Principles and Practice.* 1952 539 pp $5.00 John Wiley & Sons. (#212)

FOULK, C. W., MOYER, H. V., and MCNEVIN, W. M. *Quantitative Chemical Analysis.* 1952 465 pp $5.00 McGraw-Hill. (#213)

GRIFFIN, CARROLL W. *Inorganic Quantitative Analysis.* 3rd Edition 1954 417 pp $4.75 The Blakiston Co., Inc. (#214)

HAMILTON, L. F., and SIMPSON. S. G. *Quantitative Chemical Analysis.* 10th Edition 1952 259 pp $4.75 The Macmillan Company. (#215)

HARTSUCH, B. B. *Elementary Quantitative Analysis.* 1943 274 pp $3.75 John Wiley & Sons. (#216)

KIRK, P. L. *Quantitative Ultramicroanalysis.* 1950 310 pp $6.00 John Wiley & Sons. (#217)

KOLTHOFF, I. M., and SANDELL, E. B. *Textbook of Quantitative Inorganic Analysis.* 3rd Edition 1952 768 pp $6.50 The Macmillan Company. (#218)

MCNEVIN, WILLIAM MARSHALL, and SWEET, THOMAS RICHARD. *Quantitative Analysis.* 1952 247 pp $3.75 Harper & Brothers. (#219)

MELLON, M. G. *Quantitative Analysis Record Book.* 1944 200 pp Hard Cover $1.00 Thomas Y. Crowell Company (#220)

PATTERSON, ANDREW, JR., and THOMAS, HENRY C. *A Textbook of Quantitative Analysis.* 1952 500 pp $4.25 Henry Holt and Company. (#221)

PETERS, JOHN P., and VAN SYLKE, DONALD D. *Quantitative Clinical Chemistry.* (Volume I—Interpretations) 2nd Edition 1946 1050 pp $7.00 Williams & Wilkins Co. (#222)

PIERCE, W. C., and HAENISCH, E. L. *Quantitative Analysis.* 3rd Edition 1948 520 pp $5.00 John Wiley & Sons. (#223)

RIEMAN, W. NEUSS, J. D., and NAIMAN, B. *Quantitative Analysis.* 1951 3rd Edition 523 pp $5.50 McGraw-Hill (#224)

SIGGIA, SIDNEY. *Quantitative Organic Analysis via Functional Groups.* 2nd Edition 1954 227 pp $5.00 John Wiley & Sons. (#225)

SWIFT, ERNEST, *Introductory Quantitative Analysis.* 1950 472 pp $4.95 Prentice-Hall, Inc. (#226)

VAN PEURSEM, R. L., and IMES, H. C. *Elementary Quantitative Analysis.* 1953 383 pp $4.50 McGraw-Hill. (#227)

WEST, PHILIP W. *Calculation of Quantitative Analysis.* 1948 162 pp $2.75 The Macmillan Company. (#228)

WILLARD, HOBART H., and DIEHL, HARVEY. *Advanced Quantitative Analysis.* 1943 457 pp. $5.75 D. Van Nostrand Company, Inc. (#229)

Prentice-Hall
COLLEGE TEXTS

GRIGNARD REACTIONS OF NONMETALLIC SUBSTANCES

by M. S. KHARASCH and OTTO REINMUTH, University of Chicago

This book presents the first attempt at coordinated theoretical treatment of Grignard reactions and represents the nearest thing to an exhaustive literature survey yet achieved. The preparations and properties of the Grignard reagents have been treated in great detail (Chaps. II–V) and the division of subject matter into chapters has been made on the basis of co-reactants, or groups of closely related co-reactants.

1440 pages • 6″ x 9″ • Published September 1954

INTRODUCTION TO STATISTICAL THERMODYNAMICS

by MALCOLM DOLE, Northwestern University

Bridging the gap between thermodynamics and kinetics on the one hand and even more important, between chemistry and physics on the other, Dr. Dole's book is unique in its simplicity of approach in a field which another author (Nobel Laureate Schrodinger) declared "conceptionally so enormously difficult."

270 pages • 5⅝″ x 8⅜″ • Published June 1954

GENERAL BIOCHEMISTRY

by WILLIAM H. PETERSON and F. M. STRONG, University of Wisconsin

This new book provides a general coverage of all the fundamentals of biochemistry—including not only animal biochemistry but that of plants and microbial organisms. It includes simple, direct accounts of recent advances in knowledge of hormones, photosynthesis, and nitrogen fixation, and provides a study of energy metabolism which is more detailed than that in most textbooks.

448 pages • 6″ x 9″ • Published April 1953

CHEMICAL THERMODYNAMICS

Basic Theory and Methods

by IRVING M. KLOTZ, Northwestern University

This book presents the foundations and interrelationships of the theory of thermodynamics and shows the student how to apply these principles to practical problems. Necessary mathematical tools and computational techniques are fully described and illustrated.

416 pages • 6″ x 9″ • Published September 1950

PRENTICE-HALL, INC. 70 FIFTH AVENUE, NEW YORK 11

WILLARD, HOBERT H., and FURMAN, N. HOWELL. *Elementary Quantitative Analysis, Theory and Practice.* 3rd Edition 1940 531 pp $4.75 D. Van Nostrand Company, Inc. (#230)

WILLARD, HOBART H., FURMAN, N. HOWELL, and FLAGG, JOHN F. *A Short Course in Quantitative Analysis.* 1943 253 pp $3.75 D. Van Nostrand Company, Inc. (#231)

ORGANIC

ABERNETHY, JOHN LEO. *Principles of Organic Chemistry* 1949 317 pp $4.00 W. B. Saunders Company. (#232)

ADAMS, R. *Organic Reactions.* Volume V 1949 446 pp $8.00 John Wiley & Sons. (#233)

ADAMS, R. *Organic Reactions.* Volume VI 1951 517 pp $9.00 John Wiley & Sons. (#234)

ADAMS, ROGER, ET AL., Editors. *Organic Reactions.* Volume VII 440 pp $9.00 John Wiley & Sons. (#235)

ADAMS, R. *Organic Reactions.* Volume VIII 1954 Approx 486 pp Approx $9.00 John Wiley & Sons. (#236)

ALEXANDER, E. R. *Principles of Ionic Reactions.* 2nd Edition 1954 000 pp $00.00 John Wiley & Sons. (#237)

ALLEN, C. F. H. *Chemistry of Heterocyclic Compounds.* Edited by Arnold Weissberger. (Volume II—Six-Membered Heterocyclic Nitrogen Compounds with Four Condensed Rings) 1951 359 pp $10.00 Price to subscribers $9.00 Interscience Publishers, Inc. (#238)

AMUNDSEN, LAWRENCE H. *Organic Chemistry.* 1954 384 pp $4.75 Henery Holt and Company. (#239)

ANDERSON, LEIGH C., and BACHMANN, WERNER E. *A Manual for the Organic Chemistry Laboratory.* 1953 164 pp $2.75 John Wiley & Sons. (#240)

ARNOLD, RICHARD T., ET AL. Editors. *Organic Syntheses.* Volume XXXII 1952 119 pp $3.50 John Wiley & Sons. (#241)

ASTLE, MELVIN J., and SHELTON, J. REID. *Organic Chemistry.* 1953 771 pp $7.50 Harper & Brothers. (#242)

BACHMAN, G. B. *Organic Chemistry.* 1949 432 pp $5.00 McGraw-Hill. (#243)

BADGER, G. M. *The Structures and Reaction of the Aromatic Compounds.* 1954 456 pp $11.50 Cambridge University Press. (#244)

BAMBAS, L. L. *Chemistry of Heterocyclic Compounds.* Edited by Arnold Weissberger. (Volume IV—Five-Membered Heterocyclic Compounds with Nitrogen and Sulfur or Nitrogen, Sulfur and Oxygen, except Thiazole) 1952 416 pp $14.00 Price to subscribers $12.60 Interscience Publishers, Inc. (#245)

BOORD, C. E., BORDE, W. R., and BROSSERT, R. G. *Laboratory Outlines and Notebook for Organic Chemistry.* 2nd Edition 1949 282 pp $3.25 John Wiley & Sons. (#246)

BOUNDY, R. H., and BOYER, R. F. *Styrene.* 1952 1321 pages $20.00 Reinhold Publishing Corp. (#247)

BRANCH, GERALD, and CALVIN, MELVIN. *The Theory of Organic Chemistry, An Advanced Course.* 1941 523 pp $5.95 Prentice-Hall, Inc. (#248)

BRAUNS, F. E. *Chemistry of Lignin.* 1952 808 pp $14.50 Academic Press, Inc. (#249)

BREWSTER, RAY. *Organic Chemistry.* 2nd Edition 1953 855 pp $7.00 Prentice-Hall, Inc. (#250)

BREWSTER, RAY. *Organic Chemistry, A Brief Course.* 1949 409 pp $5.00 Prentice-Hall, Inc. (#251)

CALDWELL, W. T. *Organic Chemistry.* 1943 763 pp $5.50 Houghton Mifflin Company. (#252)

CAMPAIGNE, E., HART, H., and SCHUETZ, R. D. *Laboratory Manual for A Short Course in Organic Chemistry.* 1953 153 pp $2.50 Houghton Mifflin Company. (#253)

CASON, JAMES, and RAPOPORT, HENRY. *Laboratory Text in Organic Chemistry.* 1950 416 pp $4.25 Prentice-Hall, Inc. (#254)

CASSIDY, HAROLD GOMES. *Technique of Organic Chemistry Series.* (Volume V—Adsorption and Chromatography) 1951 380 pp $7.50 Interscience Publishers, Inc. (#255)

CHERONIS, NICHOLAS D. *Organic Chemistry.* 1941 728 pp $6.00 Thomas Y. Crowell Company. (#256)

CHERONIS, NICHOLAS D. *Semimicro and Macro Organic Chemistry.* 1942 388 pp plus 110 pp of Questions and Report Forms $3.75 Thomas Y. Crowell Company. (#257)

CHERONIS, NICHOLAS D., and ENTRIKIN, JOHN B. *Semimicro Qualitative Organic Analysis.* 1947 498 pp $5.00 Thomas Y. Crowell Company. (#258)

CONANT, JAMES B., and BLATT, ALBERT N. *Chemistry of Organic Compounds.* 4th Edition 1952 665 pp $6.00 The Macmillan Company. (#259)

CONANT, JAMES B., and BLATT, ALBERT N. *Fundamentals of Organic Chemistry.* 1950 413 pp $4.50 The Macmillan Company. (#260)

COPE, A. C. *Organic Syntheses.* Volume XXX 1950 115 pp $3.00 John Wiley & Sons. (#261)

CRAMER, FRIEDERICH. *Paper Chromatography.* 2nd Edition Revised and enlarged 1954 107 pp $5.00 St. Martin's Press. (#262)

DAY, ALLAN R. *Electronic Mechanisms of Organic Reactions.* 1950 314 pages $2.50 American Book Company. (#263)

DEGERING, E. F. *An Outline of Organic Chemistry.* 7th Edition 1947 412 pp $1.50 Barnes & Noble. (#264)

DEGERING, E. F. *An Outline of Organic Nitrogen Compounds.* 5th Edition 1950 752 pp $8.75 Ed F. Degering. (#265)

DEGERING, E. F. *Fundamental Organic Chemistry.* 2nd Edition 1948 500 pp $4.50 Ed F. Degering. (#266)

DEGERING, E. F. *The Quadri-Service Manual of Organic Chemistry.* 1942 211 pp $3.50 Houghton Mifflin Company. (#267)

DEGERING, E. F. *The Work-Book of Fundamental Organic Chemistry.* 1947 256 pp $1.75 Ed F. Degering. (#268)

DESHA, L. J. *Organic Chemistry.* 2nd Edition 1952 565 pp $6.50 McGraw-Hill. (#269)

DUNLOP, A. P., and PETERS, F. N. *Furans.* 1953 892 pp $18.00 Reinhold Publishing Corp. (#270)

ELDERFIELD, R. C. *Heterocylic Compounds.* Volume I 1950 703 pp $15.00 John Wiley & Sons. (#271)

ELDERFIELD, ROBERT C., Editor ET AL. *Heterocyclic Compounds.* (Volume II—Polycyclic Five- and Six-Membered Compounds Containing One O or S Atom) 1951 571 pp $15.00 John Wiley & Sons. (#272)

ELDERFIELD, ROBERT C., Editor, ET AL. *Heterocyclic Compounds.* (Volume III—Polycyclic Derivatives of Pyrrole; Polycyclic Systems with One Nitrogen Common to Both Rings; Pyridine and Related Compounds) 1952 442 pp $12.00 John Wiley & Sons. (#273)

ELDERFIELD, ROBERT C., Editor ET AL. *Heterocyclic Compounds.* (Volume IV—Quinoline, Isoquinoline, and their Benzo Derivatives) 1952 674 pp $17.00 John Wiley & Sons. (#274)

ENGLISH, J., and CASSIDY, H. *Principles of Organic Chemistry.* 1949 500 pp $6.25 McGraw-Hill. (#275)

FERGUSON, LLOYD. *Electron Structures of Organic Molecules.* 1952 350 pp $6.50 Prentice-Hall, Inc. (#276)

FIESER, LOUIS F. *Experiments in Organic Chemistry.* 2nd Edition 1941 498 pp $4.25 D. C. Heath and Company. (#277)

FIESER, LOUIS F., and FIESER, MARY. *Organic Chemistry.* 2nd Edition 1950 1140 pp $8.00 D. C. Heath and Company. (#278)

FIESER, LOUIS F., and FIESER, MARY. *Textbook of Organic Chemistry.* 1950 749 pp $7.00 D. C. Heath and Company. (#279)

FRIEDEL, R. A., and ORCHIN, M. *Ultraviolet Spectra of Aromatic Compounds.* 1951 708 pp $12.00 John Wiley & Sons (#280)

FRIESS, S. L., and WEISSBERGER, A., Editors. *Technique of Organic Chemistry.* (Volume VIII—Investigation of Rates and Mechanisms of Reactions) 1953 784 pp $13.50 Interscience Publishers, Inc. (#281)

FUSON, R. C. *Advanced Organic Chemistry.* 1950 669 pp $8.50 John Wiley & Sons. (#282)

FUSON, R. C., CONNOR, R., PRICE, C. C., and SNYDER, H. R. *Brief Course in Organic Chemistry.* Revised 1947 267 pp $3.75 John Wiley & Sons. (#283)

FUSON, REYNOLD C., and SNYDER, H. R. *Organic Chemistry.* 2nd Edition 1954 544 pp $6.50 John Wiley & Sons. (#284)

GARARD, I. D. *Introduction to Organic Chemistry.* 3rd Edition 1948 396 pp $4.25 John Wiley & Sons. (#285)

GETCHELL, R. W. *Organic Chemistry: A Brief Course.* 1953 278 pp $4.00 McGraw-Hill. (#286)

GILLAM, A., and STERN, E. S. *An Introduction to Electronic Absorption Spectroscopy in Organic Chemistry.* 1953 266 pp $8.00 St. Martin's Press. (#287)

GILMAN, H. *Organic Chemistry: An Advanced Treatise.* Volume III 1953 607 pp $8.75 John Wiley & Sons. (#288)

GILMAN, HENRY, Editor ET AL. *Organic Chemistry: An Advanced Treatise.* Volume IV 1953 692 pp $8.75 John Wiley & Sons. (#289)

GRUENER, HIPPOLYTE, and LANKELMA, HERMAN P. *Organic Chemistry.* 1939 533 pp $3.75 American Book Company (#290)

HART, HAROLD, and SCHUETZ, R. D. *A Short Course in Organic Chemistry.* 1953 326 pp $4.75 Houghton Mifflin Company. (#291)

HARTOUGH, HOWARD D. *Chemistry of Heterocyclic Compounds Series.* Edited by Arnold Weissberger (Volume III—Thiophene and Its Derivatives) 1952 533 pp $16.50 Price to subscribers $15.00 Interscience Publishers, Inc. (#292)

HARTOUGH, H. D., and MEISEL, S. L. *Chemistry of Heterocyclic Compounds.* Edited by Arnold Weissberger (Volume VII—Compounds with Condensed Thiophenic Rings) 1954 532 pp $16.50 Price to subscribers $15.00 Interscience Publishers, Inc. (#293)

HOFMANN, KLAUS. *Chemistry of Heterocyclic Compounds Series.* Edited by Arnold Weissberger (Volume VI—Imidazole and its Derivatives) Part I 1953 465 pp $13.50 Price to subscribers $12.25 Interscience Publishers, Inc. (#294)

New Academic Press Publications

The Alkaloids: Chemistry and Physiology

(Complete in 5 volumes)

Edited by R. H. F. MANSKE and H. L. HOLMES

Volume IV, 1954, x, 357 pages, illustrated, $8.50

Contributors: W. R. Ashford, A. Burger, G. Dalma, M. Kulka, R. H. F. Manske, L. Reti, J. Stanek, E. S. Stern.

Reviewer's comments: ". . . the complete standard work on plant alkaloids."

—Archives of Biochemistry and Biophysics

Biological Applications of Freezing and Drying

Edited by R. J. C. HARRIS

1954, xii, 415 pages, illustrated, $10.00

The aim of this book is to provide *for the first time* a comprehensive and authoritative treatise on many aspects of freezing and freeze-drying. It will serve as a work of reference for all those engaged with the techniques and as a guide to those who have yet to employ them.

Contributors: L. G. Beckett, R. E. Billingham, E. W. Flosdorf, R. M. Fry, R. Gane, I. Gersh, R. I. N. Greaves, R. J. C. Harris, D. C. Hetherington, G. G. A. Mastenbroek, J. H. Singer, A. U. Smith, J. L. Stephenson, M. M. Strumia, R. C. Williams.

Biochemistry of Cancer

Second edition, completely reset, revised, and enlarged by 250 pages

By JESSE P. GREENSTEIN

1954, xiv, 653 pages, illustrated, $12.00

Contents: Introduction, The Oncological Sciences, The General Phenomena and Taxonomy of Cancer, The Induction of Tumors, Attempts at Control of Tumor Induction and of Tumor Growth, The Properties of Tumors, Author Index, Subject Index.

Reviewer's comments on the first edition: ". . . a scholarly and discriminating treatise which is so lucid in style of writing and so logically presented it is fascinating reading. The book is a 'must' for the cancer investigator . . ."

—Journal of Chemical Education

Ion Transport Across Membranes

Incorporating Papers Presented at a Symposium Held at the College of Physicians and Surgeons, Columbia University, October 1953

Editor: HANS T. CLARKE; *Associate Editor:* DAVID NACHMANSOHN

1954, xii, 298 pages, illustrated, $7.50

Contributors: J. J. Blum, P. Debye, S. Dray, J. T. Edsall, H. Eyring, S. L. Friess, E. Grim, F. R. N. Gurd, T. L. Hill, J. F. Hoffman, A. F. Huxley, J. G. Kirkwood, M. F. Morales, G. H. Munde, D. Nachmansohn, R. Neihof, W. J. V. Osterhout, R. B. Parlin, A. K. Parpart, G. Scatchard, K. Sollner, H. H. Ussing, I. B. Wilson.

Chemical Pathways of Metabolism

(Complete in 2 volumes)

Edited by DAVID M. GREENBERG

Here is a complete, authoritative and up-to-date presentation of the pathways and mechanisms of the chemical transformations and reactions of the foodstuffs and cellular constituents in the living organism. Each chapter is written by an authority on the subject who is actively engaged in research in that field.

Volume I, 1954, xii, 460 pages, illustrated, $11.00

Contributors: G. W. Brown, Jr., I. L. Chaikoff, S. Cohen, D. E. Green, D. K. Fukushima, W. Z. Hassid, H. A. Krebs, A. B. Pardee, R. S. Rosenfeld, P. K. Stumpf.

Volume II, 1954, 383 pages, approx. $11.00

Contributors: H. Borsook, P. P. Cohen, D. M. Greenberg, S. Granick, L. A. Heppel, M. P. Schulman.

Name Reactions in Organic Chemistry

By A. R. SURREY

1954, viii, 192 pages, $4.00

In the literature of organic chemistry there is a time-honored custom of designating many reactions by the names of the chemists who discovered or developed them. These "name reactions" constitute a considerable portion of the tools available to the organic chemist. The general plan was to present a description of each reaction, its scope, applicability, and limitations, and to bring it up to date in regard to any new developments.

1954 catalogue available upon request

ACADEMIC PRESS INC.

125 East 23 Street, New York 10, N. Y.

HOLMAN, R. T., LUNDBERG, W. O., and MALKIN, T., Editors. *Progress in the Chemistry of Fats and Other Lipids.* Volume II 1954 347 pp $9.80 Academic Press, Inc. (#295)

HORNING. *Organic Syntheses.* Collective Volume III 1954 898 pp $15.00 John Wiley & Sons. (#296)

HOUBEN-WEYL. *Methoden der organischen Chemie.* 4th Edition Revised In 15 volumes, published in irregular order. Volume VII Part 1—Aldehyde. 1954 556 pp $19.50 (10% discount on orders for the whole work) U. S. A. Distributors: Intercontinental Medical Book Corporation. (#297)

HUDSON, C. S., and WOLFROM, M. L., Editors. *Advances in Carbohydrate Chemistry.* Volume VIII 1953 405 pp $10.00 Academic Press, Inc. (#298)

HUNTRESS, E. H. *Organic Chlorine Compounds.* 1948 1443 pp $27.50 John Wiley & Sons. (#299)

HUNTRESS, E. H., and MILLIKIN, S. P. *Identification of Pure Organic Compounds.* Order I 1941 691 pp $10.00 John Wiley & Sons. (#300)

INGOLD, C. K. *Structure and Mechanism in Organic Chemistry.* 1953 835 pp $9.75 Cornell University Press. (#301)

JORDAN, T. EARL. *Vapor Pressure of Organic Compounds.* 1954 608 pp $14.50 Interscience Publishers, Inc. (#302)

KARRER, P. *Lehrbuch der organischen Chemie.* 12th Edition Revised 1953 949 pp $14.20 U. S. A. Distributors: Intercontinental Medical Book Corporation. (#303)

KARRER, P. *Organic Chemistry.* 4th English Edition (in two volumes paper-bound) 1950 1000 pp Set $3.75 Elsevier Press. (#304)

KHARASCH, M. S., EISENDRATH, CARL and REINMUTH, OTTO. *Grignard Reagents of Non-Metallic Substances.* 1954 1267 pp. $12.00 Prentice-Hall, Inc. (#305)

KOSOLAPOFF, G. M. *Organophosphorus Compounds.* 1950 376 pp $12.00 John Wiley & Sons. (#306)

LOWY, A., and BALDWIN, W. E. *A Laboratory Book of Elementary Organic Chemistry.* 3rd Edition 1949 186 pp $5.50 John Wiley & Sons. (#307)

LOWY, A., HARROW, B., and APFELBAUM, P. M. *An Introduction to Organic Chemistry.* 1951 480 pp $5.50 John Wiley & Sons. (#308)

LUCAS, H. J., and PRESSMAN, D. *Principles and Practice in Organic Chemistry.* 1949 557 pp $6.00 John Wiley & Sons. (#309)

LUCAS, HOWARD J. *Organic Chemistry.* 2nd Edition 1953 766 pp $7.00 American Book Company. (#310)

MANN, FREDERICK GEORGE. *The Chemistry of Heterocyclic Compounds Series.* Edited by Arnold Weissberger (Volume I—The Heterocyclic Derivatives of Phosphorus, Arsenic, Antimony, Bismuth and Silicon) 1950 190 pp $5.25 Price to subscribers $4.20 Interscience Publishers, Inc. (#311)

MANSKE, R. H. F., and HOLMES, H. L., Editors. *The Alkaloids.* Volume IV 1954 357 pp $8.50 Academic Press, Inc. (#312)

MULDOON, HUGH C. *Organic Chemistry.* 3rd Edition 1948 648 pp $6.50 The Blakiston Co., Inc. (#313)

MCELVAIN, SAMUEL M. *The Characterization of Organic Compounds.* 2nd edition 1953 303 pp $4.50 The Macmillan Company. (#314)

NOLLER, CARL R. *Chemistry of Organic Compounds.* 1951 885 pp $7.50 W. B. Saunders Company. (#315)

NOLLER, CARL R. *Textbook of Organic Chemistry.* 1951 643 pp $5.75 W. B. Saunders Company. (#316)

PORTER, C. W., and STEWART, T. D. *The Essentials of Organic Chemistry.* Revised Edition 1953 394 pp $5.00 Ginn and Company. (#317)

PRICE, CHARLES C., Editor. *Organic Syntheses: An Annual Publication of Satisfactory Methods for the Preparation of Organic Chemicals.* Volume XXXIII 1953 115 pp $3.50 John Wiley & Sons. (#318)

RADT, F., Editor. *Elsevier's Encyclopaedia of Organic Chemistry.* (Volume 12B Part 7—Naphthalene: Carboxylic Acids) 1953 694 pp $42.00 Elsevier Press. (#319)

RADT, F., Editor. *Elseviers' Encyclopaedia of Organic Chemistry.* (Volume 14—Tetracyclic Compounds) 1940 736 pp $45.00 Elsevier Press. (#320)

RADT, F., Editor. *Elsevier's Encyclopaedia of Organic Chemistry.* (Volume 14 Supplement II—Triterpenes) 1952 490 pp $30.00 Elsevier Press. (#321)

RALSTON, A. W. *Fatty Acids and Their Derivatives.* 1948 986 pp $15.00 John Wiley & Sons. (#322)

REMICK, A. E. *Electronic Interpretations of Organic Chemistry.* 2nd Edition 1949 600 pp $7.00 John Wiley & Sons. (#323)

RICHTER, G. H. *Laboratory Manual of Elementary Organic Chemistry.* 2nd Edition 1951 146 pp $1.96 John Wiley & Sons. (#324)

RICHTER, GEORGE HOLMES. *Textbook of Organic Chemistry.* 3rd Edition 1952 762 pp $6.75 John Wiley & Sons. (#325)

RIETZ, EDWARD, and POLLARD, CASH. *Problems in Organic Chemistry.* 1953 332 pp $3.95 Prentice-Hall, Inc. (#326)

ROBERTSON, G. Ross. *Laboratory Practice of Organic Chemistry.* 3rd Edition 1954 377 pp $4.00 The Macmillan Company. (#327)

ROBERTSON, J. MONTEATH. *Organic Crystals and Molecules: Theory of X-Ray Structure Analysis with Applications to Organic Chemistry.* 1953 351 pp $5.00 Cornell University Press. (#328)

RODD, E. H. *Chemistry of Carbon Compounds.* Volume Ia 1951 777 pp $20.75 Elsevier Press. (#329)

RODD, E. H. *Chemistry of Carbon Compounds.* Volume IB 1952 684 pp $17.50 Elsevier Press. (#330)

RODD, E. H. *Chemistry of Carbon Compounds.* Volume IIa 1953 550 pp $12.50 Elsevier Press. (#331)

RODD, E. H. *Chemistry of Carbon Compounds.* Volume IIb 1954 650 pp $16.00 Elsevier Press. (#332)

ROYALS, E. EARL. *Advanced Organic Chemistry.* 1954 858 pp $10.00 Prentice-Hall, Inc. (#333)

SCHREIBER, R. S., Editor ET AL. *Organic Syntheses.* Volume XXXI 1951 122 pp $3.50 John Wiley & Sons. (#334)

SCHWENCK, J. RAE, and MARTIN, RAYMOND M. *Basic Organic Chemistry.* 1951 323 pp $5.50 The Blakiston Co., Inc. (#335)

SHIRLEY, D. A. *Preparation of Organic Intermediates.* 1951 328 pp $8.00 John Wiley & Sons. (#336)

SHRINER, R. L., and FUSON, R. C. *Systematic Identification of Organic Compounds.* 3rd Edition 1948 370 pp $5.00 John Wiley & Sons. (#337)

SIMPSON, J. C. E. *Chemistry of Heterocyclic Compounds Series.* Edited by Arnold Weissberger. (Volume V—Condensed Pyridazine and Pyrazine Rings—Cinnolines, Phthalazines and Quinoxalines) 1953 410 pp $12.50 Price to subscribers $11.25 Interscience Publishers, Inc. (#338)

STEYERMARK, AL. *Quantitative Organic Microanalysis.* 1951 389 pp $7.00 The Blakiston Co., Inc. (#339)

SUMPTER, W. C., and MILLER, F. M. *Chemistry of Heterocyclic Compounds Series.* Edited by Arnold Weissberger. (Volume VIII—Heterocyclic Compounds with Indole and Carbazole Systems) 1954 319 pp $10.00 Price to subscribers $9.00 Interscience Publishers, Inc. (#340)

SURREY, ALEXANDER ROBERT. *Name Reactions in Organic Chemistry.* 1954 192 pp $4.00 Academic Press, Inc. (#341)

SUTER, C. M. *Organic Chemistry of Sulfur.* 1944 858 pp $12.00 John Wiley & Sons. (#342)

THEILHEIMER, W. *Synthetic Methods of Organic Chemistry.* Volume I (in English) 1948 264 pp $8.50 Interscience Publishers, Inc. (#343)

THEILHEIMER, W. *Synthetic Methods of Organic Chemistry.* Volume II (in English) 1949 336 pp $8.50 Interscience Publishers, Inc. (#344)

THEILHEIMER, W. *Synthetic Methods of Organic Chemistry.* Volume III (in German with an English translation key) 1949 420 pp $11.25 Interscience Publishers, Inc. (#345)

THEILHEIMER, W. *Synthetic Methods of Organic Chemistry.* Volume IV (in German with an English translation key) 1950 372 pp $10.25 Interscience Publishers, Inc. (#346)

THEILHEIMER, W. *Synthetic Methods of Organic Chemistry.* Volume V (in English) 1951 624 pp $16.50 Interscience Publishers, Inc. (#347)

THEILHEIMER, W. *Synthetic Methods of Organic Chemistry.* Volume VI (in English) 1952 412 pp $13.50 Interscience Publishers, Inc. (#348)

THEILHEIMER, W. *Synthetic Methods of Organic Chemistry.* Volume VII (In English) 1953 462 pp $15.00 Interscience Publishers, Inc. (#349)

THEILHEIMER, W. *Synthetic Methods of Organic Chemistry.* Volume VIII (in English) 1954 528 pp $18.90 Interscience Publishers, Inc. (#350)

TIMMERMANS, J. *Physico-Chemical Constants of Pure Organic Compounds.* 1950 694 pp $12.50 Elsevier (#351)

TOBOLSKY, A. V., and MESROBIAN, R. B. *Organic Peroxides: Their Chemistry, Decomposition, and Role in Polymerization.* 1954 207 pp $5.75 Interscience Publishers, Inc. (#352)

UNDERKOFLER, LELAND A. *A Brief Introduction to Organic Chemistry.* 1953 352 pp $4.25 D. Van Nostrand Company, Inc. (#353)

VOGEL, ARTHUR I. *Practical Organic Chemistry.* 2nd Edition. 1951 1033 pp $10.00 Longmans. (#354)

WAGNER, ROMEO B., and ZOOK, HARRY D. *Synthetic Organic Chemistry.* 1953 887 pp $11.50 John Wiley & Sons. (#355)

WATERS, WILLIAM A. *Physical Aspects of Organic Chemistry.* 4th Edition 1950 539 pp College Edition $6.00 Reference Edition $8.00 D. Van Nostrand Company, Inc. (#356)

WELCHER, FRANK J. *Organic Analytical Reagents.* Volume I 1947 444 pp $9.25 D. Van Nostrand Company, Inc. (#357)

WELCHER, FRANK J. *Organic Analytical Reagents.* Volume II 1947 530 pp $9.25 D. Van Nostrand Company, Inc. (#358)

WELCHER, FRANK J. *Organic Analytical Reagents.* Volume III 1947 593 pp $9.25 D. Van Nostrand Company, Inc. (#359)

WELCHER, FRANK J. *Organic Analytical Reagents.* Volume IV 1948 530 pp $9.25 D. Van Nostrand Company, Inc. (#360)

WERTHEIM, EDGAR. *Experiments in Organic Chemistry.* 2nd Edition 1950 221 pp $2.50 The Blakiston Co., Inc. (#361)

Please

NEW REPRINTS

Now Available:

G. LINDAU ET P. SYDOW

Thesaurus litteraturae mycologicae et lichenologicae

5 volumes, 1908–1917

Cloth bound set	$100.00
Paper bound set	90.00

Pharmacological Reviews

Volumes 1–2, 1949–1950

Paper bound	$15.00 each

Zeitschrift für Angewandte Mathematik und Mechanik

Volumes 1–20, 1921–1940

Cloth bound set	$425.00
Single volumes, paper bound	20.00 each

Ready Fall 1954:

The Botanical Gazette

Volumes 1–20, 1875–1895

Cloth bound set	$340.00
Single volumes, paper bound	15.00 each

Projected reprint:

Volumes 21–26, 1896–1919

Ready December 1954:

Journal of Physical Chemistry

Volumes 31–33, 1927–1929 (approximately 2,000 pages per volume)
Single volumes, paper bound, about $40.00 each

Volumes 34–36, 1930–1932 (approximately 3,000 pages per volume)
Single volumes, paper bound, about $50.00 each

Previously reprinted:

Volumes 37–55, 1933–1951

Paper bound set	$475.00
Single volumes, paper bound	25.00 each

In Preparation:

Journal of Pharmacology and Experimental Therapeutics

Volumes 1–20, 1909–1922

Cloth bound set	$425.00
Single volumes, paper bound	20.00 each

Monatshefte für Mathematik und Physik

Volumes 1–51, 1890–1944

Cloth bound set	$850.00
Single volumes, paper bound	15.00 each

Complete list of reprints available on request

JOHNSON REPRINT CORPORATION

125 East 23 Street, New York 10, N. Y.

Let's Look It Up!

CHEMISTRY
CHEMICAL ENGINEERING
MATERIALS ENGINEERING
METALLURGY

. . . including the latest American Chemical Society Monographs

DETERIORATION OF MATERIALS—Causes and Preventive Techniques Edited by GLENN A. GREATHOUSE and CARL J. WESSEL

This important book, prepared with the collaboration of 23 specialists, describes and analyzes the causes of deterioration and presents tried and proven techniques for preventing or retarding such deterioration. Covers a wide variety of materials in common use today. Profusely illustrated and thoroughly indexed.

1954, 768 pages, illustrated, about $14.00

THE CHEMISTRY OF PETROLEUM HYDROCARBONS (3 Volumes)—edited by BENJ. T. BROOKS, CECIL E. BOORD, STEWART S. KURTZ and LOUIS SCHMERLING

These three volumes constitute what is probably the most valuable source of information on the scientific fundamentals of hydrocarbon chemistry. Though the objective is to emphasize the chemistry of the hydrocarbons themselves, the chemistry of many industrial processes involving hydrocarbon chemistry is included, as are the probable mechanisms of many hydrocarbon reactions and physical methods of studying the structure of complex petroleum hydrocarbons.

Vol. I, 1954, Size and price to be announced
Vol. II, 1954, Size and price to be announced
Vol. III, 1955, Size and price to be announced

MANUFACTURE AND APPLICATION OF LUBRICATING GREASES—by C. J. BONER

Without doubt, this is the most complete treatise ever published on the subject. It begins by explaining the structure and theory of lubricating greases and follows with full chapters on raw materials, processes and manufacturing equipment. Lubricants containing specific thickeners, including such recent developments as lithium soaps, complex soaps and non-soap gelling agents, are then discussed in full detail. Complete information is given on the effects of each ingredient or treatment upon the characteristics of the final product, and the methods of evaluating these characteristics by either chemical or physical means. Many industrial applications of lubricating greases and future trends in their chemistry and technology comprise the concluding section of this book.

1954, size and price to be announced

ATOMIC AND FREE RADICAL REACTIONS—2nd Edition, in 2 Volumes, by E. W. R. STEACIE

Now thoroughly revised and brought up to date, this new edition of Steacie's outstanding monograph reflects all the newest developments on the subject of elementary organic reactions in the gaseous phase. With their considerable amount of important new information, these two volumes will be a welcome addition to all technical libraries, research laboratories, and to the personal reference shelves of research chemists and physicists.

1954, ACS Monograph, Appr. 896 pages, $28.00 the set

MONOMERIC ACRYLIC ESTERS, by EDWARD H. RIDDLE

This valuable new book provides industrial chemists and chemical engineers with a wealth of practical, up-to-date information on the properties, polymerization, copolymerization and chemical reactions of commercially available acrylate and methacrylate esters. Also fully covered are methods of storing and handling, explosive limits, toxicity and latest methods of determining purity.

1954, 195 pages, about $5.00

PLASTICS ENGINEERING HANDBOOK of the Society of the Plastics Industry

This brand-new edition of the famous *S.P.I. Handbook*, now published by Reinhold, offers a completely up-to-date compilation of the best engineering knowledge available on the processing of plastics. Organized in the same logical pattern as previously, this edition has been greatly expanded to include the latest engineering data on materials, molding and forming techniques, design, finishing and testing. Everyone familiar with the *S.P.I. Handbook* will welcome this new revision for its even greater contribution to the growing knowledge of the plastics industry.

1954, 856 pages, $15.00

ELEMENTS OF FOOD ENGINEERING in 3 Vols.—by MILTON E. PARKER, E. H. HARVEY and E. S. STATELER

Treats the production, preparation, processing, handling and distribution of foods from the *unit operation* and *unit process* points of view. Vol. I outlines the engineering factors involved in food processing and describes in detail the agricultural and nutritional aspects of food production, the extent of the food processing industries, major classifications of foods and refined foods processing. Vols. II and III present a unified, coordinated discussion of unit operations grouped according to specific function. As the first book to be published in this new field, it will be welcomed by engineers, chemists and technologists in all of the food processing industries.

Vol. I: 1952, 386 pages, $8.75
Vol. II: 1954, 360 pages, $8.50
Vol. III: 1954, 256 pages, $6.75

FIBERGLAS REINFORCED PLASTICS, edited by RALPH H. SONNEBORN

The first complete treatment ever published on the subject of reinforced plastics. Written for both the design engineer and for executives in the materials industries, it covers in full detail the resins and glass reinforcements used in reinforcing plastics, gives molding techniques, data on inspection and testing, on properties and design considerations. Provides all those concerned with reinforced plastics with much valuable and practical information never before available in one compact volume.

1954, 350 pages, $4.50

ADHESIVE BONDING OF METALS (a Reinhold Pilot Book)—by GEORGE EPSTEIN

Gives enough details so an engineer or technician faced with the problem of joining two materials will be able to determine whether an adhesive-bonded joint would be advantageous, what types of adhesive to select, how to employ it, and how to design the joint for optimum performance. Special emphasis is placed on adhesives which are most often employed with metals. An entire chapter is devoted to elevated-temperature-resistant adhesives for metals—a development required by the progress made in higher speed aircraft and missile production.

1954, 170 pages, 4½" x 6¼", $2.95

RARE METALS HANDBOOK—edited by CLIFFORD A. HAMPEL

Assembled here for the first time in one handy source is the latest available data on over 30 of the less common metallic elements—previously little known but now playing more important roles in modern technology. Information on each element is arranged for quick reference to such important aspects as: occurrence, production, statistics, economics, derivation, physical and chemical properties, fabrication techniques, alloys and applications.

1954, 850 pages, $12.00

THE TECHNICAL REPORT: Its Preparation and Use in Industry and Government—edited by B. H. WEIL

Covers the fundamentals of writing, editing, illustrating, duplicating, binding, distributing, security filing, and putting report files to work. Will have wide appeal among writers, technical editors, graphics arts groups, librarians, research and technical personnel connected with the use of reports as a means of information transfer.

1954, 485 pages, $12.00

REINHOLD PUBLISHING CORPORATION

—roster of recent REINHOLD books—

TITANIUM AND TITANIUM ALLOYS (A Reinhold Pilot Book)—by JOHN L. EVERHART

This concise and amazingly useful little book is the first to review the progress made to date in titanium technology. It summarizes and coordinates the extensive periodical literature which has appeared in widely scattered publications since titanium became an important commercial material. The author places major emphasis on the properties, fabrication, machinery and applications of commercial titanium and those alloys now in production. As a timely source of reliable and useful data, this book will be indispensable to every materials engineer, designer and plant metallurgist.

1954, 184 pages, 4½" x 6½", $3.00

CHEMICAL ENGINEERING IN PRACTICE—edited by JAMES I. HARPER

Based on a symposium entitled: "Chemical Engineering in the Process Industries" presented under the joint auspices of the Philadelphia-Wilmington Section of the American Institute of Chemical Engineers and the University of Pennsylvania, this highly readable book describes the varied roles of the chemical engineer in industry and shows how the various phases of research are integrated to produce the best overall result. Harper's work will prove of great interest and value to chemical engineers at all levels, to students who must choose their specialized fields of endeavor, and to management men who must organize and direct the coordinated efforts of various engineering teams.

1954, 148 pages, $3.00

COPPER: The Science and Technology of the Metal; Its Alloys and Compounds—edited by ALLISON BUTTS

Almost every phase of the chemistry and metallurgy of copper, its alloys and compounds are covered in this amazingly comprehensive book. 46 big chapters, each by one or more specialists on the subject, cover all the important fundamental principles, latest practices, and many of the lesser-known uses of copper.

1954, ACS Monograph, 936 pages, $20.00

THE PROPERTIES OF GLASS, 2nd Edition—by GEORGE W. MOREY

Thoroughly up to date, this new edition of Morey's famous monograph is much larger than its predecessor, and contains many more tables and illustrations. Of great value to both the scientist and the lay reader who wishes authoritative current information on glass in general.

1954, ACS Monograph, 595 pages, $16.50

MODERN CHEMICAL PROCESSES (In 3 Volumes)—by the Editorial Staff of *Industrial and Engineering Chemistry*

This series (the 3rd Vol. of which is now ready) is destined to become a perpetual inventory of American chemical technology and the most valuable reference source of its kind. Will be used continuously by practicing industrial chemists, chemical engineers, and advanced students in those fields.

Vol. I, 1950, 230 pages, 8" x 11", $5.00
Vol. II, 1952, 290 pages, 8" x 11", $5.00
Vol. III, 1954, 280 pages, 8" x 11", $5.00

VEGETABLE FATS AND OILS—by E. W. ECKEY

All the important vegetable fats and oils are fully described and arranged according to the botanical relationships among the plants which produce them. Numerous tables provide quick comparisons of related fats and oils. This work will prove of daily value to all chemists engaged in producing, processing or utilizing vegetable fats and oils.

1954, ACS Monograph, 864 pages, $16.50

INDUCTION AND DIELECTRIC HEATING—by J. WESLEY CABLE

Here is a well-organized treatment of the latest uses and applications of high-frequency heating in industry. Divided into two major sections, covering induction and dielectric heating respectively, the book contains sufficient theory to enable the reader to fully understand the basic phenomena applicable to both methods.

1954, 620 pages, illustrated, $12.50

CATALYSIS, Vol. I—by PAUL H. EMMETT, Mellon Institute

Provides research chemists with the best-integrated, most soundly conceived treatise ever published on the physical chemistry of catalysis and catalytic processing. Covers not only the long-established ideas and interpretations, but also the ever-widening range of concepts upon which modern catalytic techniques are based. Much space in Vol. I is devoted to catalyst supporters, carriers and methods of preparation.

Vol. I, 1954, 410 pages, $10.00

CHEMICAL PROCESS MACHINERY, new 2nd Edition—by E. RAYMOND RIEGEL

This greatly enlarged edition of Riegel's widely adopted work brings it abreast of latest developments in the equipment of the chemical and process industries. Scores of new diagrams, photographs and tables make the construction and operation of recently employed machinery readily understandable to students and laymen as well as to engineers.

1954, 740 pages, $12.50

HYDROCARBONS FROM PETROLEUM—ROSSINI

This vitally important work brings together in one volume the results of 26 years' work by the American Petroleum Institute Research Project 6 on the composition of petroleum, the fractionation and analysis of hydrocarbons, the development of fractionating processes, purification, and the measurement of the physical properties of hydrocarbons. Clear, authoritative information is offered on the principles of fractionating processes; the development and operation of apparatus for fractionating by distillation, extraction, absorption and crystallization; purification and purity determinations of hydrocarbons, analysis of hydrocarbons, and many other vital topics. Unusually complete literature references close each chapter, and a complete list of references to papers of the API Research Project is contained in the appendix.

1953, ACS Monograph, 850 pages, $18.50

PRACTICAL CHROMATOGRAPHY—BRIMLEY and BARRETT

Here for the first time is a concise, factual introduction to chromatography which includes *all* the latest methods, equipment and important applications. It covers the paper, adsorption, ion-exchange and partition methods of chromatography, together with the most recent apparatus; gives first the techniques of the methods under discussion, then the applications to chemical and biological research. Detailed instructions and diagrams are provided for setting up chromatograms which may be used for rapid identifications of reactions and hydrolyses, and for purity determinations.

1953, 128 pages, illustrated, $5.00

TEXTILE FIBERS, YARNS AND FABRICS: A Comparative Survey of Their Behavior, with Special Reference to Wool—by ERNEST R. KASWELL

Based directly on the research results of over 400 investigators, this eagerly awaited book is the first to evaluate the engineering, physical and chemical behavior of textile fibers, yarns and fabrics—both natural and synthetic.

The first part of the book deals with the intrinsic properties of the fibers themselves. In the second section, the relationships of these properties to the fundamental fabric requirements are explained in unusual detail. All fibers, including such recent synthetics as Dacron, Vicara, X-51 and others are fully discussed.

1953, 450 pages, $11.00

INDUSTRIAL WASTES: Their Treatment and Disposal—edited by WILLEM RUDOLFS, ACS Monograph #118

This monograph by 18 experts offers a thorough, completely up-to-date study of disposal problems of the meat-packing, leather, pulp and paper, coal and other industries. The physical, chemical and biological considerations of each type of problem are developed in full detail. You'll find complete information on the scope of the waste treatment problem in general, the basic principles of stream pollution and self-purification, and modern views, theories and applications of individual treatment problems. Ample attention is also given to the volumes and characteristics of wastes and to the recovery of by-products. Recent developments, including radioactive waste treatment, are given special emphasis.

1953, 500 pages, $9.50

STARCH: Its Sources, Production and Uses—by CHARLES A. BRAUTLECHT

This is the first complete survey of the sources, processing and uses of starch ever published. Here, in 21 chapters, the author discusses such important aspects as microscopic characteristics of industrial starches, the economics of various plant materials, technology, specifications, physical and chemical characteristics, methods of analysis and uses. New processes and equipment are described in unusual detail. Although major emphasis is placed on potato starch, latest information on such other starch sources as corn, sweet potatoes, tapioca, wheat and rice are also included.

1953, 400 pages, $10.00

Send for on-approval Copies.

Dept. M-707, 430 Park Avenue, New York 22, N. Y.

WERTHEIM, EDGAR. *Introductory Organic Chemistry.* 2nd Edition 1948 473 pp $4.25 The Blakiston Co., Inc. (#362)

WERTHEIM, EDGAR. *Laboratory Guide for Organic Chemistry.* 3rd Edition 1948 457 pp $3.75 The Blakiston Co., Inc. (#363)

WERTHEIM, EDGAR. *Practical Organic Chemistry.* 1953 383 pp $3.00 The Blakiston Co., Inc. (#364)

WERTHEIM, EDGAR. *Textbook of Organic Chemistry.* 3rd Edition 1951 958 pp $6.00 The Blakiston Co., Inc. (#365)

WHELAND, G. W. *Advanced Organic Chemistry.* 2nd Edition 1949 799 pp $8.50 John Wiley & Sons. (#366)

WHELAND, G. W. *Theory of Resonance and Its Application to Organic Chemistry.* 1944 316 pp $6.00 John Wiley & Sons. (#367)

WHISTLER, ROY L., and SMART, CHARLES L. *Polysaccharide Chemistry.* 1953 493 pp $10.80 Academic Press, Inc. (#368)

WHITMORE, FRANK C. *Organic Chemistry.* 2nd Edition 1951 960 pp College Edition $9.00, Reference Edition $12.00 D. Van Nostrand Company, Inc. (#369)

WILD, F. *Characterisation of Organic Compounds.* 1948 306 pp $4.50 Cambridge University Press. (#370)

WILLIAMS, ROGER J., and HATCH, LEWIS F. *An Introduction to Organic Chemistry.* 5th Edition 1948 668 pp $4.75 D. Van Nostrand Company, Inc. (#371)

WINCHELL, A. N. *The Optical Properties of Organic Compounds.* 2nd Edition 1954 487 pp $12.00 Academic Press, Inc. (#372)

WISE, LOUIS E., and JAHN, EDWIN C. *Wood Chemistry.* Volume I 1952 730 pp $15.00 Reinhold Publishing Corp. (#373)

WISE, LOUIS E., and JAHN, EDWIN C. *Wood Chemistry.* Volume II 1952 595 pp $15.00 Reinhold Publishing Corp. (#374)

PHYSICAL CHEMISTRY

AMIS, EDWARD S. *Kinetics of Chemical Change in Solution.* 1949 354 pp $6.00 The Macmillan Company. (#375)

BABOR, JOSEPH A., and THIESSEN, GARRETT W. *How to Solve Problems in Physical Chemistry.* 1944 215 pp $2.00 Thomas Y. Crowell Company. (#376)

BAK, BØRGE. *Elementary Introduction to Molecular Spectra.* 1953 135 pp $2.90 Interscience Publishers, Inc. (#377)

BELL, R. P. *Acids and Bases.* 1952 90 pp $1.50 John Wiley & Sons. (#378)

BIKERMAN, J. J., BOOTH, R. B., and CURRIE, C. C. *Foams, Theory and Industrial Application.* 1953 347 pp $10.00 Reinhold Publishing Corp. (#379)

BOTTCHER, C. J. F. *Theory of Electric Polarisation.* 1952 492 pp $10.00 Elsevier Press. (#380)

BRODE, W. R. *Chemical Spectroscopy.* 2nd Edition 1943 679 pp College Edition $7.50 John Wiley & Sons. (#381)

BROWN, G. I *Introduction to Modern Valency Theory.* 1953 176 pp $2.50 Longmans. (#382)

BUCKLEY, H. E. *Crystal Growth.* 1951 571 pp $10.00 John Wiley & Sons. (#383)

CLARK, WILLIAM MANSFIELD. *Topics in Physical Chemistry.* 2nd Edition 1952 803 pp $10.00 Williams & Wilkins Co. (#384)

CLARKE, H. T., Editor. *Ion Transport Across Membranes.* 1954 298 pp $7.50 Academic Press, Inc. (#385)

CROCKFORD, H. C., and KNIGHT, S. P. *Fundamentals of Physical Chemistry for Premedical Students.* 1950 366 pp $4.50 John Wiley & Sons. (#386)

DANIELS, F. *Outlines of Physical Chemistry.* 1948 713 pp $6.00 John Wiley & Sons. (#387)

DANIELS, F., MATHEWS, J. H., and WILLIAMS, J. W. *Experimental Physical Chemistry.* 4th Edition 1949 568 pp $6.00 McGraw-Hill. (#388)

DEBYE, PETER J. W. *Collected Papers of Peter J. W. Debye.* 1954 722 pp $9.50 Interscience Publishers, Inc. (#389)

DENBIGH, K. G. *The Thermodynamics of the Steady State.* 1952 103 pp $1.75 John Wiley & Sons. (#390)

EITEL, WILHELM. *The Physical Chemistry of the Silicates.* 1954 1575 pp $30.00 The University of Chicago Press. (#391)

ELLIS, R. B., and MILLS, A. P. *Laboratory Manual in Physical Chemistry.* 1953 96 pp $3.50 McGraw-Hill. (#392)

EMMETT, P. H. *Catalysis.* Vol. I 1954 410 pages $10.00 Reinhold Publishing Corp. (#393)

EYRING, H., WALTER J., and KIMBALL, G. D. *Quantum Chemistry.* 1944 394 pp $6.50 John Wiley & Sons. (#394)

FARKAS A. *Physical Chemistry of the Hydrocarbons.* Volume I 1950 453 pp $11.50 Academic Press, Inc. (#395)

FARKAS, A. *Physical Chemistry of the Hydrocarbons.* Volume II 1953 411 pp $11.50 Academic Press, Inc. (#396)

FINDLAY, ALEXANDER, and KITCHNER, J. A. *Practical Physical Chemistry.* 8th Edition 1954 364 pp $3.50 Longmans. (#397)

FLORY. PAUL J. *Principles of Polymer Chemistry.* 1953 688 pp $8.50 Cornell University Press. (#398)

FRANKENBURG, W. G., KOMAREWSKY, V. I., and RIDEAL, E. K., Editors. *Advances in Catalysis and Related Subjects.* Volume VI 1954 000 pp $0.00 Academic Press, Inc. (#399)

FROST, ARTHUR A., and PEARSON, RALPH G. *Kinetics and Mechanism: A Study of Homogeneous Chemical Reactions.* 1953 343 pp $6.00 John Wiley & Sons. (#400)

GARRETT, C. G. B. *Magnetic Cooling.* 1954 130 pp $4.50 John Wiley & Sons. (#401)

GLASSTONE, SAMUEL. *The Elements of Physical Chemistry.* 1946 695 pp $5.50 D. Van Nostrand Company, Inc. (#402)

GLASSTONE, SAMUEL. *Textbook of Physical Chemistry.* 2nd Edition 1946 1320 pp College Edition, $10.00 Reference Edition, $12.50 D. Van Nostrand Company, Inc. (#403)

GLASSTONE, SAMUEL. *Theoretical Chemistry.* 1944 515 pp $6.50 D. Van Nostrand Company, Inc. (#404)

GLASSTONE, SAMUEL. *Thermodynamics for Chemists.* 1947 522 pp $5.50 D. Van Nostrand Company, Inc. (#405)

GLASSTONE, S., LAIDLER, K. J., and EYRING, H. *Theory of Rate Processes.* 1941 611 pp $9.50 McGraw-Hill. (#406)

GUCKER, FRANK THOMSON, JR., and MELDRUM, WILLIAM BUELL. *Physical Chemistry.* 1950 695 pp $4.00 American Book Company. (#407)

GURNEY, R. W. *Ionic Processes in Solution.* 1953 275 pp $6.50 McGraw-Hill. (#408)

HAMMETT, L. P. *Introduction to the Study of Physical Chemistry.* 1952 421 pp $6.00 McGraw-Hill. (#409)

HARKINS, W. D. *Physical Chemistry of Surface Films.* 1952 430 pp $10.00 Reinhold Publishing Corp. (#410)

HIRSCHFELDER, JOSEPH O., CURTISS, CHARLES F., and BIRD, R. BYRON. *Molecular Theory of Gases and Liquids.* 1954 1219 pp $20.00 John Wiley & Sons. (#411)

HITCHCOCK, DAVID. *Physical Chemistry.* 1953 304 pp $5.00 Little, Brown & Company. (#412)

HOBER, RUDOLF. *Physical Chemistry of Cells and Tissues.* 1945 676 pp $6.00 The Blakiston Co., Inc. (#413)

JASPER, J. J. *Laboratory Methods of Physical Chemistry.* 1938 312 pp $3.75 Houghton Mifflin Company. (#414)

JOHNSON, EYRING, and POLISSAR. *The Kinetic Basis of Molecular Biology.* 1954 874 pp $15.00 John Wiley & Sons. (#415)

KETELAAR, J. A. A. *Chemical Constitution.* 1953 398 pp $6.50 Elsevier Press. (#416)

KOLLER, LEWIS R. *Ultraviolet Radiation.* 1952 270 pp $7.00 John Wiley & Sons. (#417)

KOLTHOFF, I. M., and LINGANE, JAMES J. *Polarography.* 2nd Edition Revised and augmented In two volumes (Volume I—Theoretical Principles and Instrumentation and Technique) 1952 438 pp $11.00 Interscience Publishers, Inc. (#418)

KOLTHOFF, I. M., and LINGANE, JAMES J. *Polarography.* 2nd Edition Revised and augmented In two volumes (Volume II—Inorganic and Organic Polarography, Biological Applications, and Amperometric Titrations) 1952 568 pp $12.50 Interscience Publishers, Inc. (#419)

KLOTZ, IRVING. *Chemical Thermodynamics.* 1950 416 pp $6.50 Prentice-Hall, Inc. (#420)

LAIDLER, K. J. *Chemical Kinetics.* 1950 408 pp $6.50 McGraw-Hill. (#421)

LEWIS, WARREN K., SQUIRES, LOMBARD, and BROUGHTON, GEOFFREY. *Industrial Chemistry of Colloidal and Amorphous Materials.* 1942 540 pp $6.00 The Macmillan Company. (#422)

LONDON, F. *Superfluids.* Volume II 1954 214 pp $6.00 John Wiley & Sons. (#423)

LUDER, W. F., and ZUFFANTI, S. *Electronic Theory of Acids and Bases.* 1946 165 pp $4.50 John Wiley & Sons. (#424)

MACDOUGALL, FRANK H. *Physical Chemistry.* 3rd Edition 1952 722 pp $6.00 The Macmillan Company. (#425)

MATSEN, F. A., MYERS, JACK, and HACKERMAN, NORMAN. *Pre-Medical Physical Chemistry.* 1949 344 pp $4.75 The Macmillan Company. (#426)

MAYER, J. E., and MAYER, M. G. *Statistical Mechanics.* 1940 495 pp $6.50 John Wiley & Sons. (#427)

MOILLIET, J. L., and COLLIE, B. *Surface Activity.* 1951 379 pp $12.50 D. Van Nostrand Company, Inc. (#428)

MOORE, WALTER. *Physical Chemistry.* 1950 640 pp $6.50 Prentice-Hall, Inc. (#429)

NOYES, ARTHUR A., and SHERRILL, MILES S. *Course of Study in Chemical Principles.* 2nd Edition 1938 554 pp $6.25 The Macmillan Company. (#430)

PARTINGTON, J. R. *An Advanced Treatise on Physical Chemistry.* (Vol. IV—Physico-Chemical Optics) 1953 688 pp $15.50 Longmans. (#431)

PAUL, M. *Principles of Chemical Thermodynamics.* 1950 740 pp $8.50 McGraw-Hill. (#432)

PAULING, L., and WILSON, E. B. *Introduction to Quantum Mechanics with Applications to Chemistry.* 1935 468 pp $6.50 McGraw-Hill. (#433)

If you make it a point to examine . . .

Just Published

The Fundamentals of College Chemistry

Second Edition

G. Brooks King, The State College of Washington
William E. Caldwell, Oregon State College

"This text fills the needs of our beginning course more closely than any of more than 30 texts examined. The order of presentation, the choice of words, diagrams, and illustrations are sensible and teachable."
—H. H. Rowley, University of Oklahoma

Extensively revised, enlarged, and brought up to date, this book continues to answer the need for a beginning chemistry text that the student can master with a minimum of help from the instructor. It presents the basic facts and principles of chemistry clearly and simply. For every problem the student is asked to solve, at least one illustrative example is provided. An important feature of the Second Edition is the increase in the number of problems from 390 to 604. Answers are provided for approximately half of the numerical problems.

Recently Published

Organic Chemistry

Second Edition

Howard J. Lucas, California Institute of Technology

"This revision brings an excellent textbook up to date. I like the way the introductory chapters orient the student's thinking in the direction of physico-organic chemistry."—Carl R. Meloy, University of Illinois

"An outstanding feature is the number and quality of the problems at the end of each chapter."—Robert K. Ingham, Ohio University

"A solid presentation of the fundamentals of elementary organic chemistry. Very up-to-date on facts and replete with principles the student will use throughout his career in chemistry."—Joseph Bornstein, Boston College

. . . you'll be *so* glad you did!

American Book Company

COLLEGE DIVISION, 55 FIFTH AVENUE, NEW YORK 3, N. Y.

PITZER, KENNETH. *Quantum Chemistry.* 1953 529 pp $7.50 Prentice-Hall, Inc. (#434)

PLESCH, P. H., Editor. *Ationic Polymerisation and Related Complexes.* 1953 159 pp $4.00 Academic Press, Inc. (#435)

PRUTTON, CARL F., and MARON, SAMUEL H. *Fundamental Principles of Physical Chemistry.* 2nd Edition 1951 820 pp $6.00 The Macmillan Company. (#436)

REES, A. L. G. *Chemistry of the Defect Solid State.* (Methuen's Monographs on Chemical Subjects Series) 1954 136 pp $2.00 John Wiley & Sons. (#437)

REILLY, JOSEPH, and RAE, WILLIAM NORMAN. *Physico-Chemical Methods.* 5th Edition In three volumes Volume I 1954 751 pp $15.00 D. Van Nostrand Company, Inc. (#438)

REILLY, JOSEPH, and RAE, WILLIAM NORMAN. *Physico-Chemical Methods.* 5th Edition In Three volumes Volume II 1954 789 pp $15.00 D. Van Nostrand Company, Inc. (#439)

REILLY, JOSEPH, and RAE, WILLIAM NORMAN. *Physico-Chemical Methods.* 5th Edition In three volumes Volume III 1954 679 pp $15.00 D. Van Nostrand Company, Inc. (#440)

RICCI, JOHN E. *The Phase Rule and Heterogeneous Equilibrium.* 1951 468 pp College Edition, $9.00 Reference Edition, $12.00 D. Van Nostrand Company, Inc. (#441)

ROBERTSON. *Mass Spectrometry.* (Methuen Series on Physical Subjects) 1954 00 pp $00.00 John Wiley & Sons. (#442)

ROLLEFSON, GERHARD, and BURTON, MILTON. *Photochemistry and the Mechanism of Chemical Reactions.* 1939 445 pp $5.75 Prentice-Hall, Inc. (#443)

ROLLEFSON, G. K., and POWELL, R. E., Editors. *Annual Review of Physical Chemistry.* Vol. IV 493 pp $7.00 Annual Reviews, Inc. (#444)

ROSSINI, F. D. *Chemical Thermodynamics.* 1950 514 pp $6.50 John Wiley & Sons. (#445)

RUTGERS, A. J. *Physical Chemistry.* 1954 820 pp $8.50 Interscience Publishers, Inc. (#446)

SHOCKLEY, W., HOLLOMON, J. H., MAURER, R., and SEITZ, F., Editors. *Imperfections in Nearly Perfect Crystals.* 1952 490 pp $9.00 John Wiley & Sons. (#447)

SMOLUCHOWSKI, R., MAYER, J. E., and WEYL, W. A., Editors. *Phase Transformations in Solids.* 1951 660 pp $10.50 John Wiley & Sons. (#448)

STEINBACH, OTTO F., and KING, CECIL V. *Experiments in Physical Chemistry.* 1950 256 pp $3.50 American Book Company. (#449)

SILLEN, LARS, LANGE, PAUL, and GABRIELSON, CARL. *Problems in Physical Chemistry.* 1952 370 pp $5.50 Prentice-Hall, Inc. (#450)

TAYLOR, HUGH S., and GLASSTONE, SAMUEL. *Atomistics and Thermodynamics.* Volume I. 3rd Edition 1942 677 pp $9.50 D. Van Nostrand Company, Inc. (#451)

TAYLOR, HUGH S., and GLASSTONE, SAMUEL. *States of Matter.* Volume II 3rd Edition 1951 701 pp $12.00 D. Van Nostrand Company, Inc. (#452)

TAYLOR, HUGH S., and TAYLOR, H. AUSTIN. *Elementary Physical Chemistry.* 3rd Edition 1942 551 pp $4.25 D. Van Nostrand Company, Inc. (#453)

VON HIPPEL. *Dielectric Materials and Applications.* 1954 489 pp $17.50 John Wiley & Sons. (#454)

WEST, EDWARD S. *Physical Chemistry for Students of Biochemistry and Medicine.* 1944 368 pp $5.00 The Macmillan Company. (#455)

ELECTROCHEMISTRY

CONWAY, B. E. *Electrochemical Data.* 1952 374 pp $8.75 Elsevier Press. (#456)

GLASSTONE, SAMUEL. *An Introduction to Electrochemistry.* 1942 557 pp $6.50 D. Van Nostrand Company, Inc. (#457)

KORTUM, G. *Textbook of Electrochemistry.* Volume I 1951 352 pp $7.00 Elsevier Press. (#458)

KORTUM, G. *Textbook of Electrochemistry.* Volume II 1951 530 pp $10.00 Elsevier Press. (#459)

MANTELL, C. L. *Industrial Electrochemistry.* 3rd Edition 1950 781 pp $9.50 McGraw-Hill. (#460)

COLLOID

CLAESSON, S., and LA MER, V. K., Editors. *Journal of Colloid Science.* Supplement I 1954 145 pp $4.00 Academic Press, Inc. (#461)

DEAN, ROBERT B. *Modern Colloids.* 1948 303 pp $5.00 D. Van Nostrand Company, Inc. (#462)

FISCHER, E. K. *Colloidal Dispersions.* 1950 387 pp $9.00 John Wiley & Sons. (#463)

GREGG, S. J. *Surface Chemistry of Solids.* 1951 307 pp $8.50 Reinhold Publishing Corp. (#464)

HARRISON, V. G. W., Editor. *Proceedings of the Second International Congress on Rheology.* 1954 451 pp $10.00 Academic Press, Inc. (#465)

HARTMAN, R. J. *Colloid Chemistry.* 2nd Edition 1947 572 pp $6.50 Houghton Mifflin Company. (#466)

KRUYT, H. R. *Colloid Science.* (Volume I—Irreversible Systems) 1952 389 pp $11.00 Elsevier Press. (#467)

KRUYT, H. R. *Colloid Science.* (Volume II—Reversible Systems) 1949 475 pp $11.50 Elsevier Press. (#468)

MCBAIN, J. W. *Colloid Science.* 1950 458 pp $6.75 D. C. Heath and Co. (#469)

RANDALL, J. T., Editor. *Nature and Structure of Collagen.* 1953 269 pp $6.50 Academic Press, Inc. (#470)

WEISER, H. B. *Colloid Chemistry: A Textbook.* 2nd Edition 1949 444 pp $6.00 John Wiley & Sons. (#471)

PHYSICS

ALLER, LAWRENCE H. *Astrophysics—The Atmospheres of the Sun and Stars.* 1953 412 pp $12.00 The Ronald Press Company. (#472)

ALLER, LAWRENCE H. *Astrophysics—Nuclear Transformations, Stellar Interiors, and Nebulae.* 1954 291 pp $12.00 The Ronald Press Company. (#473)

BALLARD, STANLEY S., SLACK, EDGAR P., and HAUSMANN, ERICH. *Physics Principles.* 1954 752 pp $7.50 D. Van Nostrand Company, Inc. (#474)

BENNETT, CLARENCE E. *First Year College Physics.* 1954 526 pp $6.00 The Ronald Press Company. (#475)

BRADDICK, H. J. *Physics of Experimental Methods.* 1954 404 pp $7.00 John Wiley & Sons. (#476)

DE GROOT, S. R. *Thermodynamics of Irreversible Processes.* 1951 250 pp $5.50 Interscience Publishers, Inc. (#477)

FEENBERG, EUGENE, and PAKE, G. E. *Quantum Theory of Angular Momentum.* 1953 63 pp $2.00 Addison-Wesley Publishing Company, Inc. (#478)

FONDA, G. R., and SEITZ, F. *Preparation and Characteristics of Solid Luminescent Materials* (National Research Council) 1948 459 pp $8.50 John Wiley & Sons. (#479)

FRETTER, WILLIAM. *Modern Experimental Procedures in Physics.* 1954 342 pp $6.75 Prentice-Hall, Inc. (#480)

HOLTON, GERALD J. *Introduction to Concepts and Theories in Physical Science.* 1953 624 pp $6.50 Addison-Wesley Publishing Company, Inc. (#481)

HUNTLEY, H. E. *Nuclear Species.* 1954 125 pp $4.50 St. Martin's Press. (#482)

KITTEL, CHARLES. *Introduction to Solid State Physics.* 1953 396 pp $7.00 John Wiley & Sons. (#483)

KRONIG, R., Editor. *Textbook of Physics.* 1954 860 pp $10.00 Interscience Publishers, Inc. (#484)

LEVERENZ, H. W. *An Introduction to Luminescence of Solids.* 1950 569 pp $15.00 John Wiley & Sons. (#485)

MARTON, L., Editor. *Advances in Electronics.* Volume V 1953 420 pp $9.50 Academic Press, Inc. (#486)

MEES, C. E. KENNETH. *The Theory of the Photographic Process.* 2nd Edition 1954 1133 pp $21.50 The Macmillan Company. (#487)

MULLER, RALPH, GARMAN, RAYMOND, and DROZ, MARCEL. *Experimental Electronics.* 1942 330 pp $5.00 Prentice-Hall, Inc. (#488)

NEWELL, HOMER EDWARD. *High Altitude Rocket Research.* 1953 298 pp $7.50 Academic Press, Inc. (#489)

PRINGSHEIM, PETER. *Fluorescence and Phosphorescence.* 1949 810 pp $18.00 Interscience Publishers, Inc. (#490)

SEARS, FRANCIS WESTON. *Thermodynamics, The Kinetic Theory of Gases, and Statistical Mechanics.* 2nd edition 1953 384 pp $7.50 Addison-Wesley Publishing Company, Inc. (#491)

STRONG, JOHN, ET AL. *Procedures in Experimental Physics.* 1938 642 pp $7.50 Prentice-Hall, Inc. (#492)

SWENSON, GEORGE W., JR. *Principles of Modern Acoustics.* 1953 222 pp $4.00 D. Van Nostrand Company, Inc. (#493)

VON HIPPEL. *Dielectrics and Waves.* 1954 287 pp $12.50 John Wiley & Sons. (#494)

WEBER, ROBERT. *Heat and Temperature Measurement.* 1950 448 pp $5.00 Prentice-Hall, Inc. (#495)

WHITE, HARVEY E. *Modern College Physics.* 2nd Edition. 1953 823 pp $6.75 D. Van Nostrand Company, Inc. (#496)

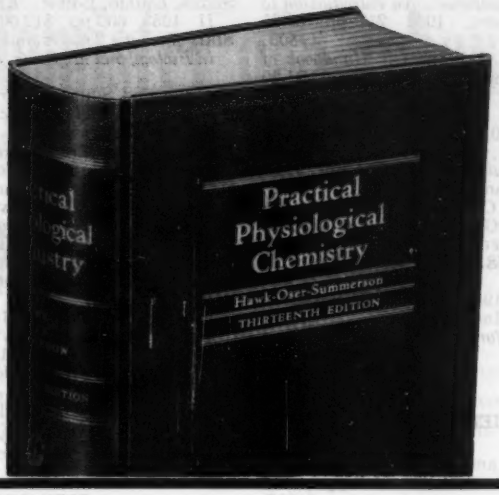
WILLIAMS, A. O., JR. *Electronics: Physical Principles and Applications.* 1953 306 pp $4.50. D. Van Nostrand Company, Inc. (#497)

ZWIKKER, C. *Physical Properties of Solid Materials.* 1954 300 pp $8.75 Interscience Publishers, Inc. (#498)

MATHEMATICS

BENNETT, CARL A., and FRANKLIN, NORMAN L. *Statistical Analysis in Chemistry and the Chemical Industry.* 1954 724 pp $8.00 John Wiley & Sons. (#499)

JUST PUBLISHED



NEW 13th EDITION

$12.00

Now Celebrating Its 50th Anniversary

Hawk, Oser and Summerson's PRACTICAL PHYSIOLOGICAL CHEMISTRY, NEW 13th Edition. This classic work was first used by Dr. Hawk as a text at the University of Pennsylvania in 1904. The new, revised 13th edition, still under Dr. Hawk's authorship, contains for the first time the contributions of more than 30 outstanding specialists whose timely material is incorporated throughout. Included in this revised edition are *new tables and illustrations*, as well as the latest advances and techniques; *new topics* such as chromotography (paper and column), ultramicroanalysis of blood, paper electrophoresis, counter current distribution, and liver function tests. Of special note are the excellent experimental sections at the end of each chapter. Besides its usefulness as a textbook, PRACTICAL PHYSIOLOGICAL CHEMISTRY is one of the most valuable references in the field. 1439 Pages; 307 Illustrations plus Color Plates **$12.00**

Just Published! Jones' GENERAL CHEMISTRY—By W. Norton Jones, Jr., Ph.D., Professor of Chemistry; Chairman of the Division of Science and Mathematics, McMurry College. A complete, integrated and up-to-date, new text for first-year chemistry students—non-science majors as well as chemistry majors, premedical and predental students. The subject matter in GENERAL CHEMISTRY is so clearly presented that even those who have had no previous background can readily grasp it. Some of the many valuable aids provided in this new work are as follows: repeated reference to topics to reinforce the student's comprehension of them; extensive bibliography at the end of each chapter; abundant exercise material—questions, problems and equations; and numerous remarkably helpful illustrations. 906 Pages; illustrated..... **$6.50**

Note These Other Important Chemistry Texts

Gero's BIOLOGICAL CHEMISTRY—380 Pages; Well Illustrated..... **$5.00**

Brescia's GENERAL COLLEGE CHEMISTRY—581 Pages..... **$6.00**

Cavelti's INTRODUCTORY GENERAL CHEMISTRY—423 Pages; 50 Illustrations..... **$4.50**

Wertheim's PRACTICAL ORGANIC CHEMISTRY—383 Pages; 23 Illustrations..... **$3.00**

Parks & Steinbach's SYSTEMATIC COLLEGE CHEMISTRY—692 Pages; 126 Illustrations.....**$5.50**

order here

THE BLAKISTON COMPANY, INC., Garden City, N. Y.

Please send me ——copies NEW 13th Edition
PRACTICAL PHYSIOLOGICAL CHEMISTRY.....$12.00
——copies Jones' GENERAL CHEMISTRY.....$ 6.50
——copies Gero's BIOLOGICAL CHEMISTRY.....$ 5.00
——copies Brescia's GENERAL COLLEGE CHEMISTRY.....$ 6.00
——Cavelti's INTRODUCTORY GENERAL CHEMISTRY.....$ 4.50
——Wertheim's PRACTICAL ORGANIC CHEMISTRY.....$ 3.00
——Parks & Steinbach's SYSTEMATIC COLLEGE CHEMISTRY$ 5.50

☐ For 90-Day Professor Examination* ☐ For Personal Use 10-Day Trial Basis
☐ Charge ☐ Check Encl. ☐ M.O. Encl.

SCIENCE BOOKS from Blakiston

*Examination Privileges Available Only in Continental U.S.A.

NAME_____
(Please Print)
ADDRESS_____
CITY_____ZONE_____STATE_____

JCE 9-54

BENSON, SIDNEY W. *Chemical Calculations: An Introduction to the Use of Mathematics in Chemistry.* 1952 217 pp $2.95 John Wiley & Sons. (#500)

BURINGTON, RICHARD S., and MAY, DONALD C. *Handbook of Probability and Statistics.* (With tables) 1953 332 pp $4.50 Handbook Publishers, Inc. (#501)

COMRIE, L. J. *Shorter Six-Figure Mathematical Tables.* 1st Amer. Edition 1954 387 pp $6.50 Chemical Publishing Co., Inc. (#502)

KAPLAN, WILFRED. *Advanced Calculus.* 1953 679 pp $8.50 Addison-Wesley Publishing Company, Inc. (#503)

LONG, J. S., and ANDERSON, H. V. *Chemical Calculations.* 5th Edition 1948 402 pp $4.50 McGraw-Hill. (#504)

MARGENAU, HENRY, and MURPHY, GEORGE M. *The Mathematics of Physics and Chemistry.* 1943 581 pp $6.50 D. Van Nostrand Company, Inc. (#505)

PERLIS, SAM. *Theory of Matrices.* 1952 237 pp $5.50 Addison-Wesley Publishing Company, Inc. (#506)

YOUDEN, W. J. *Statistical Methods for Chemists.* 1951 126 pp $3.50 John Wiley & Sons. (#507)

NUCLEAR SCIENCE

BECKERLEY, J. G., KAMEN, M. D., and SCHIFF, L. I., Editors. *Annual Review of Nuclear Science.* Vol. III 412 pp $7.00 Annual Reviews, Inc. (#508)

BEHRENS, CHARLES F., Editor. *Atomic Medicine.* 2nd Edition 1953 646 pp $11.00 Williams & Wilkins Co. (#509)

BLATT, JOHN M., and WEISSKOPF, VICTOR F. *Theoretical Nuclear Physics.* 1952 864 pp $12.50 John Wiley & Sons. (#510)

BLEULER, ERNST, and GOLDSMITH, GEORGE J. *Experimental Nucleonics.* 1952 393 pp $6.50 Rinehart & Co., Inc. (#511)

BLOOM, W. *Histopathology of Irradiation from External and Internal Sources.* 1948 809 pp $10.75 McGraw-Hill. (#512)

CALVIN, N., HEIDELBERGER, C., REID, J. C., TOLBERT, B. M., and YANKWICH, P. E. *Isotopic Carbon.* 1949 376 pp $8.50 John Wiley & Sons. (#513)

COHEN, K. P., and MURPHY, G. M. *Theory of Isotope Separation.* 1951 165 pp $2.50 McGraw-Hill. (#514)

CORYELL and SUGARMAN. *Radiochemical Studies: The Fission Products.* 1951 (In three volumes—not sold separately) 2073 pp $27.75 McGraw-Hill. (#515)

DIEKE and DUNCAN. *Spectroscopic Properties of Uranium Compounds.* 1949 308 pp $4.25 McGraw-Hill. (#516)

FRIEDLANDER, G., and KENNEDY, J. *Introduction to Radiochemistry.* 1949 412 pp $6.00 John Wiley & Sons. (#517)

GLASSTONE, SAMUEL. *Sourcebook on Atomic Energy.* 1950 562 pp $3.75 D. Van Nostrand Company, Inc. (#518)

GLASSTONE, SAMUEL, and EDLUND, MILTON C. *The Elements of Nuclear Reactor Theory.* 1953 416 pp $4.80 D. Van Nostrand Company, Inc. (#519)

GRAY, DWIGHT E., and MARTENS, JOHN H. *Radiation Monitoring in Atomic Defense.* 1951 122 pp $2.50 D. Van Nostrand Company, Inc. (#520)

HALLIDAY, DAVID. *Introductory Nuclear Physics.* 1950 558 pp $6.75 John Wiley & Sons. (#521)

HUGHES, DONALD J. *Pile Neutron Research.* 1953 399 pp $8.50 (Five or more copies for classroom use, $7.50 each) Addison-Wesley Publishing Company, Inc. (#522)

KATZ and RABINOWITCH. *The Chemistry of Uranium.* 1951 609 pp $8.25 McGraw-Hill. (#523)

KIRSHENBAUM. *Physical Properties and Analysis of Heavy Water.* 1951 456 pp $6.00 McGraw-Hill. (#524)

LAPP, RALPH and ANDREWS, HOWARD *Nuclear Radiation Physics.* 2nd Edition 1954 535 pp $6.75 Prentice-Hall, Inc. (#525)

NICKSON, JAMES J., Editor ET AL. *Symposium on Radiobiology: The Basic Aspects of Radiation Effects on Living Systems.* 1952 465 pp $10.00 John Wiley & Sons (#526)

POLLARD, E., and DAVIDSON, W. L. *Applied Nuclear Physics.* 1951 352 pp $5.50 John Wiley & Sons. (#527)

QUILL. *Chemistry and Metallurgy of Miscellaneous Materials: Thermodynamics.* 1950 329 pp $4.50 McGraw-Hill. (#528)

RAMSEY, NORMAN F. *Nuclear Moments.* 1953 169 pp $5.00 John Wiley & Sons. (#529)

RODDEN. *Analytical Chemistry of the Manhattan Project: Uranium and Thorium.* 1950 748 pp $10.00 McGraw-Hill. (#530)

SACHS, ROBERT G. *Nuclear Theory.* 1953 383 pp $7.50 Addison-Wesley Publishing Company, Inc. (#531)

SACKS, J. *Isotopic Tracers in Biochemistry and Physiology.* 1953 383 pp $8.50 McGraw-Hill. (#532)

SEABORG, G., and KATZ, J. *The Actinide Elements.* 1954 McGraw-Hill. (#533)

SEABORG, KATZ, and MANNING. *The Transuranium Elements: Research Paper.* (Two parts—not sold separately) 1949 1778 pp $23.75 McGraw-Hill. (#534)

SEGRÈ, EMILIO, Editor. *Experimental Nuclear Physics.* Volume I 1953 789 pp $15.00 John Wiley & Sons. (#535)

SEGRÈ, EMILIO, Editor. *Experimental Nuclear Physics.* Volume II 1953 600 pp $12.00 John Wiley & Sons. (#536)

SIRI. *Isotopic Tracers and Nuclear Radiations with Applications in Biology and Medicine.* 1949 653 pp $15.00 McGraw-Hill. (#537)

SLESSER and SCHRAM. *Preparation, Properties and Technology of Fluorine and Organic Fluoro Compounds.* 1951 868 pp $11.50 McGraw-Hill. (#538)

SPEARS, FREDERICK GORDON. *Radiations and Living Cells.* 1953 222 pp $3.50 John Wiley & Sons. (#539)

STEPHENSON, R. *Introduction to Nuclear Engineering.* 1954 394 pp $6.00 McGraw-Hill. (#540)

SULLIVAN, W. H. *Trilinear Chart of Nuclear Species.* 1949 6 panels. $3.75 John Wiley & Sons. (#541)

WAHL, ARTHUR C., and BONNER, NORMAN A., Editors. *Radioactivity Applied to Chemistry.* 1951 604 pp $9.50 John Wiley & Sons. (#542)

WILLIAMS, RUSSELL R., JR. *Principles of Nuclear Chemistry.* 1950 352 pp $4.75 D. Van Nostrand Company, Inc. (#543)

YAGODA, H. *Radioactive Measurements with Nuclear Emulsions.* 1949 356 pp $8.00 John Wiley & Sons. (#544)

ZIRKLE. *Biological Effects of External Beta Radiation.* 1951 242 pp $3.50 McGraw-Hill. (#545)

ZIRKLE, R. E. *Biological Effects of External X and Gamma Radiation.* 1954 $7.25 McGraw-Hill. (#546)

CHEMICAL ENGINEERING

BADGER and MCCABE. *Elements of Chemical Engineering.* 2nd Edition 1936 660 pp $7.50 McGraw-Hill. (#547)

BROWN, GEORGE GRANGER, ET AL. *Unit Operations.* 1950 612 pp $9.00 John Wiley & Sons. (#548)

DODGE, B. F. *Chemical Engineering Thermodynamics.* 1944 699 pp $8.50 McGraw-Hill. (#549)

DREISBACH, ROBERT R. *P-V-T Relationships of Organic Compounds.* 3rd Edition 1952 315 pp $10.00 Handbook Publishers, Inc. (#550)

HARPER, JAMES I. *Chemical Engineering in practice.* 1954 140 pp $3.00 Reinhold Publishing Corp. (#551)

HESSE, HERMAN C., and RUSHTON, J. HENRY. *Process Equipment Design.* 1945 580 pp College Edition, $6.50 Reference Edition, $8.00 D. Van Nostrand Company, Inc. (#552)

HOUGEN, O. A., and WATSON, K. M. *Chemical Process Principles.* Combined Edition—Volumes I, II and III 1948 1115 pp $15.00 John Wiley & Sons. (#553)

HOUGEN, O. A., and WATSON, K. M. *Chemical Process Principles Charts.* 1946 52 pp $3.50 John Wiley & Sons. (#554)

INDUSTRIAL & ENGINEERING CHEMISTRY, Editors. *Modern Chemical Processes.* Volume I 1950 230 pp $5.00 Reinhold Publishing Corp. (#555)

INDUSTRIAL & ENGINEERING CHEMISTRY, Editors. *Modern Chemical Processes.* Volume II 1952 290 pp $5.00 Reinhold Publishing Corp. (#556)

INDUSTRIAL & ENGINEERING CHEMISTRY, Editors. *Modern Chemical Processes.* Volume III 1954 276 pp $5.00 Reinhold Publishing Corp. (#557)

KERN. *Process Heat Transfer.* 1950 871 pp $12.00 McGraw-Hill. (#558)

KOWALKE, OTTO L. *Fundamentals in Chemical Process Calculations.* 1947 158 pp $3.25 The Macmillan Company. (#559)

LAUER, B. E., and HECKMAN, R. F. *Chemical Engineering Techniques.* 1952 450 pages. $6.00 Reinhold Publishing Corp. (#560)

LEWIS, BERNARD, Editor. *Fourth Symposium* (International) *on Combustion.* 1953 946 pp $7.00 Williams & Wilkins Co. (#561)

MAXWELL, J. B. *Data Book on Hydrocarbons.* 1950 270 pp $5.50 D. Van Nostrand Company, Inc. (#562)

NORDELL, ESKEL. *Water Treatment for Industrial and Other Uses.* 1951 525 pp $12.00 Reinhold Publishing Corp. (#563)

PAI, S. I. *Fluid Dynamics of Jets.* 1954 272 pp Approx $5.50 D. Van Nostrand Company, Inc. (#564)

PARKER, MILTON E. *Elements of Food Engineering.* Vol. I. 1952 390 pp $8.75 Reinhold Publishing Corp. (#565)

PERRY, J. H. *Chemical Engineer's Handbook.* 3rd Edition. 1950 1942 pp $17.00 McGraw-Hill. (#566)

RIEGEL, E. RAYMOND. *Chemical Process Machinery.* 2nd Edition. 1953 743 pp $12.50 Reinhold Publishing Corp. (#567)

ROBINSON, C. S., and GILLIAND. *The Elements of Fractional Distillation.* 4th Edition 1950 492 pp $8.50 McGraw-Hill. (#568)

RUDOLFS, WILLEM. *Industrial Wastes, Their Treatment and Disposal.* 1953 510 pp $9.50 Reinhold Publishing Corp. (#569)

SHAPIRO, ASCHER H. *The Dynamics and Thermodynamics of Compressible Fluid Flow.* In two volumes. Volume I 1953 647 pp $16.00 The set $30.00 The Ronald Press Company. (#570)

Elsevier's Chemistry of Carbon Compounds

Editor-in-Chief — Dr. E. H. Rodd, D. Sc., F.R.I.C.

Nears Its Half-Way Mark...

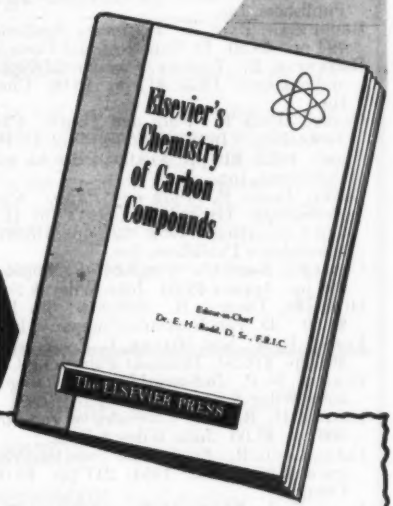
. . . Volume II B, just off the press, brings this compact coverage of chemical knowledge within sighting distance of its goal. More than ever, now, it provides the practicing organic chemist with essentially all the facts he needs in his daily work. Users and reviewers alike acclaim it as an unqualified success.

These reviews tell the story:

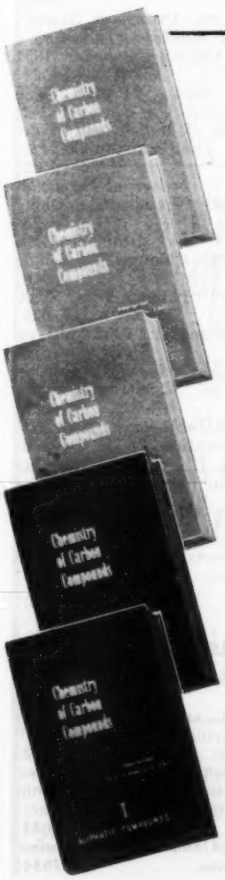
"Chemistry of Carbon Compounds" represents a landmark in the history of chemical publishing . . . certain to become a standard reference work . . ."
Journal of the American Chemical Society

"A Model of compactness and thorough coverage."
Journal of Colloid Science

"Certain to find a key position on the bookshelves of most practicing organic chemists."
Journal of Chemical Education



WRITE NOW for the new brochure that describes this much-needed series in full detail.



Elsevier's New Deferred Payment Plan...

. . . enables you to buy these volumes at the subscription price without the burden of a large cash outlay. A $5.00 down payment will bring you promptly the four published parts of "Chemistry of Carbon Compounds." Later volumes will be delivered as they are issued, and you can pay as little as $4.00 a month until the entire set has been paid for. This plan is unique because it includes no interest or other charges.

Schedule of Publication of "Chemistry of Carbon Compounds"

Volume I Aliphatic Compounds (Published)
Volume II Alicyclic Compounds (Published)
Volume III Aromatic Compounds (In Press)
Volume IV Heterocyclic Compounds (In Preparation)
Volume V Miscellaneous—General Index (In Preparation)

The ELSEVIER PRESS

402-JE Lovett Blvd.,
Houston 6, Texas

HOUSTON • NEW YORK • AMSTERDAM • LONDON • BRUSSELS

SHAPIRO, ASCHER H. *The Dynamics and Thermodynamics of Compressible Fluid Flow.* In two volumes. Volume II 1954 Approx 530 pp $16.00 The set $30.00 The Ronald Press Company. (#571)

SHERWOOD, T. K., and PIGFORD. *Absorption and Extraction.* 2nd Edition 1952 478 pp $8.00 McGraw-Hill. (#572)

STANNETT, V., and MITLIN L. *Pocket Book of Chemical Technology.* 1st Amer. Edition 1954 283 pp $4.75 Chemical Publishing Co., Inc. (#573)

STEARNS, REID F. *Flow Measurement with Orifice Meters.* 1951 384 pp $7.50 D. Van Nostrand Company, Inc. (#574)

TREYBAL. *Liquid Extraction.* 1951 422 pp $8.00 McGraw-Hill. (#575)

WALKER, LEWIS, MCADAMS, and GILLILAND. *Principles of Chemical Engineering.* 3rd Edition 1937 749 pp $7.00 McGraw-Hill. (#576)

INDUSTRIAL

ANDERSEN, AAGE JORGEN CHRISTIAN. *Refining of Oils and Fats for Edible Purposes.* 1953 204 pp $7.00 Academic Press, Inc. (#577)

BAILEY, ALTON E. *Industrial Oil and Fat Products.* 2nd Edition Revised and augmented 1951 960 pp $16.50 Interscience Publishers, Inc. (#578)

BEDOUKIAN, PAUL Z. *Perfumery Synthetics and Isolates.* 1951 494 pp $8.50 D. Van Nostrand Company, Inc. (#579)

BROWNING, E. *Toxicity of Industrial Organic Solvents.* Revised and enlarged 1953 411 pp $8.00 Chemical Publishing Co., Inc. (#580)

CASEY, JAMES P. *Pulp and Paper: Chemistry and Chemical Technology.* (In two volumes) (Vol. I—Pulping and Papermaking) 1952 819 pp $18.00 Price for set $33.00 Interscience Publishers, Inc. (#581)

CASEY, JAMES P. *Pulp and Paper: Chemistry and Chemical Technology.* (In two volumes) (Vol. II—Properties of Paper and Converting) 1952 622 pp $18.00 Price for set $33.00 Interscience Publishers, Inc. (#582)

CORLEY. *Successful Commerical Chemical Development.* 1954 390 pp Approx $9.00 John Wiley & Sons. (#583)

DURRANS, THOMAS H. *Solvents.* 6th Edition 1950 202 pp $7.50 D. Van Nostrand Company, Inc. (#584)

ECKEY, E. W., and MILLER, L. P. *Vegetable Fats & Oils.* 1954 864 pp $16.50 Reinhold Publishing Corp. (#585)

ECKMAN, D. P. *Industrial Instrumentation.* 1950 396 pp $6.00 John Wiley & Sons. (#586)

ELKINS, H. B. *The Chemistry of Industrial Toxicology.* 1950 406 pp $7.00 John Wiley & Sons. (#587)

ELLIS, CECIL B. *Fresh Water from the Ocean—For Cities, Industry and Irrigation.* 1954 217 pp $5.00 The Ronald Press Company. (#588)

FAITH, W. L., KEYES, D. B., and CLARK, R. L. *Industrial Chemicals.* 1950 652 pp $10.00 John Wiley & Sons. (#589)

FLETT, LAWRENCE H., and GARDNER, WILLIAM H. *Maleic Anhydride Derivatives: Reactions of the Double Bond.* 1952 269 pp $7.50 John Wiley & Sons. (#590)

FOX, M. R. *Vat Dyestuffs and Vat Dyeing.* 1947 323 pp $6.00 John Wiley & Sons. (#591)

FURNAS, C. C. *Roger's Manual of Industrial Chemistry.* In Two Volumes. 6th Edition. 1942 1721 pp $19.75 D. Van Nostrand Company, Inc. (#592)

GOLDMAN, F. H., and JACOBS, M. B. *Chemical Methods in Industrial Hygiene.* 1953 284 pp $3.75 Interscience Publishers, Inc. (#593)

GORDON, P. L., and DOLGIN, G. J. *Surface Coatings and Finishes.* 1954 250 pp $9.00 Chemical Publishing Co., Inc. (#594)

GREENBERG, LEON, and LESTER, DAVID. *Handbook of Cosmetic Materials: Their Properties, Uses, and Toxic Dermatologic Actions.* 1954 467 pp $12.50 Interscience Publishers, Inc. (#595)

GROGGINS, P. H. *Unit Processes in Organic Synthesis.* 4th Edition 1952 899 pp $12.50 McGraw-Hill. (#596)

GUENTHER, ERNEST. *The Essential Oils.* In six volumes Volume I 1948 458 pp $7.50 D. Van Nostrand Company, Inc. (#597)

GUENTHER, ERNEST. *The Essential Oils.* In six volumes Volume II 1949 868 pp $12.00 D. Van Nostrand Company, Inc. (#598)

GUENTHER, ERNEST. *The Essential Oils.* In six volumes Volume III 1949 805 pp $12.00 D. Van Nostrand Company, Inc. (#599)

GUENTHER, ERNEST. *The Essential Oils.* In six volumes Volume IV 1950 752 pp $12.00 D. Van Nostrand Company, Inc. (#600)

GUENTHER, ERNEST. *The Essential Oils.* In six volumes Volume V 1952 550 pp $12.00 D. Van Nostrand Company, Inc. (#601)

GUENTHER, ERNEST. *The Essential Oils.* In six volumes Volume VI 1952 544 pp $12.00 D. Van Nostrand Company, Inc. (#602)

HONIG, P. *Principles of Sugar Technology.* 1953 768 pp $15.00 Elsevier Press. (#603)

JOHNSON and AUTH. *Fuels and Combustion Handbook.* 1951 915 pp $14.00 McGraw-Hill (#604)

KUNIN, R., and MEYER, R. J. *Ion Exchange Resins.* 1950 212 pp $6.50 John Wiley & Sons. (#605)

LEE, J. A. *Materials of Construction for Chemical Process Industries.* 1950 468 pp $7.00 McGraw-Hill. (#606)

MARSDEN, CYRIL. *Solvents Manual.* 1954 440 pp $12.95 Elsevier Press. (#607)

MILLS, M. R. *An Introduction to Drying Oil Technology.* 1953 258 pp $6.50 Interscience Publishers, Inc. (#608)

MOREY, G. W. *Properties of Glass.* 2nd Edition 1954 600 pp $16.50 Reinhold Publishing Corporation. (#609)

NORTON, F. *Refractories.* 3rd Edition. 1950 782 pp $11.00 McGraw-Hill. (#610)

PAYNE, HENRY FLEMING. *Organic Coating Technology.* (Volume I: Oils, Resins, Varnishes, and Polymers) 1954 674 pp $10.00 John Wiley & Sons. (#611)

PRATT, L. S. *Chemistry and Physics of Organic Pigments.* 1947 359 pp $7.00 John Wiley & Sons. (#612)

RIEGEL, E. RAYMOND. *Industrial Chemistry.* 5th Edition 1949 1020 pp $8.00 Reinhold Publishing Corp. (#613)

RHODES, T. J. *Industrial Instruments for Measurement and Control.* 1941 573 pp $7.50 McGraw-Hill. (#614)

ROCHOW, E. G. *An Introduction to the Chemistry of the Silicones.* 2nd Edition 1951 213 pp $6.00 John Wiley & Sons. (#615)

SANDERSON, R. T. *Vacuum Manipulation of Volatile Compounds.* 1948 162 pp $4.50 John Wiley & Sons. (#616)

SCHEFLAN, LEOPOLD, and JACOBS, MORRIS B. *The Handbook of Solvents.* 1953 728 pp $10.00 D. Van Nostrand Company, Inc. (#617)

SCHWARTZ, ANTHONY M., and PERRY, JAMES W. *Surface Active Agents.* 590 pp $12.00 Interscience Publishers, Inc. (#618)

SHREVE. *Chemical Process Industries.* 1945 957 pp $10.00 McGraw-Hill. (#619)

SOCIETY OF CHEMICAL INDUSTRY, ENGLAND. *Annual Report on the Progress of Applied Chemistry.* Volume XXXVIII—1953 1954 Approx 850 pp Approx $6.50 Interscience Publishers, Inc. (#620)

STORCH, HENRY H., GOLUMBIC, NORMA, and ANDERSON, ROBERT B. *The Fischer-Tropsch and Related Syntheses, Including a Summary of Theoretical and Applied Contact Catalysis.* 1951 610 pp $12.00 John Wiley & Sons. (#621)

SYMPOSIUM. *Fire Retardant Paints.* 1954 91 pp $2.50 American Chemical Society. (#621-1)

TAYLOR, EDWIN WINDLE. *Examination of Waters and Water Supplies.* 6th Edition 1949 $16.50 The Blakiston Co., Inc. (#622)

UNDERKOFLER, L. A., and HICKEY, R. J. *Industrial Fermentations.* Volume I 1954 565 pp $12.00 Chemical Publishing Co., Inc. (#623)

UNDERKOFLER, L. A., and HICKEY, R. J. *Industrial Fermentations.* Volume II 1954 575 pp $12.00 Chemical Publishing Co., Inc. (#624)

VAIL, JAMES G. *Soluble Silicates.* Vol. I 1952 369 pp $9.00 Reinhold Publishing Corporation. (#625)

VAIL, JAMES G. *Soluble Silicates.* Volume II 1952 684 pp $15.00 Reinhold Publishing Corp. (#626)

VICKERSTAFF, THOMAS. *The Chemistry of Dyeing.* 2nd Edition Revised and augmented 1954 509 pp $7.50 Interscience Publishers, Inc. (#627)

VON FISCHER, WILLIAM *Paint & Varnish Technology.* 1948 505 pp $8.00 Reinhold Publishing Corporation. (#628)

VON FISCHER, WILLIAM, and BOBALEK, E. *Organic Protective Coatings.* 1953 384 pp $7.50 Reinhold Publishing Corporation. (#629)

WHITE, JOHN. *Yeast Technology.* 1954 432 pp $8.00 John Wiley & Sons. (#630)

WILLIAMS, K. A. *Oils, Fats and Fatty Foods.* 3rd Edition 1950 500 pp $10.00 The Blakiston Co., Inc. (#631)

PLASTICS AND ELASTICS

(Including Polymer Science)

ALFREY, TURNER, JR., BOHRER, JOHN J., and MARK, H. *High Polymers Series* (Volume VIII—Copolymerization) 1952 279 pp $8.00 Interscience Publishers, Inc. (#632)

BLAIR, G. W. SCOTT, Editor. *Deformation and Flow Series.* (Volume IV—Foodstuffs: their plasticity, fluidity and consistency) 1953 280 pp $7.25 Interscience Publishers, Inc. (#633)

D'ALELIO, G. F. *Experimental Plastics and Synthetic Resins.* 1946 185 pp $5.00 John Wiley & Sons. (#634)

Texts and Manuals

Smith's COLLEGE CHEMISTRY
6th EDITION

By William F. Ehret

677 pages, $5.00

Smith's INTRODUCTORY COLLEGE CHEMISTRY 3rd EDITION

By William F. Ehret

511 pages, $4.50

PROPERTIES and NUMERICAL RELATIONSHIPS of the COMMON ELEMENTS and COMPOUNDS
5th EDITION

By J. E. Belcher and J. C. Colbert

366 pages, $3.00

EXPERIMENTS and PROBLEMS for COLLEGE CHEMISTRY
5th EDITION

By J. E. Belcher and J. C. Colbert

214 pages, $2.50

INORGANIC QUALITATIVE ANALYSIS
3rd EDITION

By Harold A. Fales and Frederic Kenny

284 pages, $3.00

Appleton-Century Crofts

Publishers of THE NEW CENTURY CYCLOPEDIA OF NAMES

35 West 32nd St., New York 1, N. Y.

A Line-Formula Chemical Notation

by WILLIAM J. WISWESSER

The Wiswesser chemical notation uses a single line of letters, numbers, and punctuation marks (as found on the keyboard of a standard typewriter) to express even the most complicated chemical structures. Easily learned and easy to remember, its potentialities in saving time and preventing ambiguity are almost unlimited.

1954 149 pages 5⅝ x 8⅜ Hard Cover

$2.00

Basic College Chemistry

Second Edition

by JOSEPH A. BABOR, *The City College of New York*

"Exceptionally well written"—"good discussion of the periodic table"—"adopted because of the ease with which the beginning student will start the course"—"I like the questions and problems at the ends of chapters"—these are some of the comments received from users and future users.

1953 766 pages 155 figures 5⅝ x 8⅜

$5.50

Laboratory Problems in General Chemistry

by HOWARD NECHAMKIN, *Pratt Institute*

"The choice of experiments is excellent and of the type that encourages thinking." "One of the best laboratory manuals I have seen. The student is called upon to consider the laboratory as a challenging part of the course."

1953 274 pages 19 figures 5⅝ x 8⅜ Hard Cover

$2.50

SEE THESE and other Crowell chemistry texts in the Chemical Education Book Exhibit at the ACS. For further information or examination copies (give name of college and course) write:

THOMAS Y. CROWELL CO.

432 Fourth Avenue

New York 16, New York

D'ALELIO, G. F. *Fundamental Principles of Polymerization: Rubbers, Fibers, Plastics.* 1952 517 pp $13.50 John Wiley & Sons. (#635)

FREY-WYSSLING, A., Editor. *Deformation and Flow Series.* (Volume I—Deformation and Flow in Biological Systems) 1952 560 pp $11.50 Interscience Publishers, Inc. (#636)

GREEN, H. S. *Deformation and Flow Series.* (Volume II—Molecular Theory of Fluids) 1952 288 pp $5.75 Interscience Publishers, Inc. (#637)

HERMANS, J. J., Editor. *Deformation and Flow Series.* (Volume IV—Flow Properties of Disperse Systems) 1953 450 pp $9.90 Interscience Publishers, Inc. (#638)

HILL, ROWLAND. *Fibers from Synthetic Polymers.* 1953 565 pp $12.50 Elsevier Press. (#639)

MARK, H., and TOBOLSKY, A. V. *High Polymers Series.* (Volume II—Physical Chemistry of High Polymeric Systems) 2nd Edition Revised and augmented 1950 520 pp $7.50 Interscience Publishers, Inc. (#640)

MASON, J. PHILLIP, and MANNING, JOSEPH F. *Technology of Plastics and Resins.* 1945 494 pp College Edition, $6.00 Reference Edition, $7.00 D. Van Nostrand Company, Inc. (#641)

MEREDITH, R., Editor. *Deformation and Flow Series.* (Volume III—Mechanical Properties of Wood and Paper) 1953 300 pp $7.25 Interscience Publishers, Inc. (#642)

MONCRIEFF, R. W. *Artificial Fibres.* 2nd Edition 1954 455 pp $6.00 John Wiley & Sons. (#643)

SCHILDKNECHT, CALVIN E. *Vinyl and Related Polymers: Their Preparations, Properties and Applications in Rubbers, Plastics, Fibers, and in Medical and Industrial Arts.* 1952 723 pp $15.00 John Wiley & Sons. (#644)

SCHMIDT and MARLIES. *Principles of High-Polymer Theory and Practice.* 1948 742 pp $12.00 McGraw-Hill. (#645)

SIMONDS, HERBERT R., WEITH, ARCHIE W. and BIGELOW, M. H. *Handbook of Plastics.* 2nd Edition. 1949 1511 pp $25.00 D. Van Nostrand Company, Inc. (#646)

WHITBY. *ACS Synthetic Rubber Monograph.* 1954 870 pp $9.00 John Wiley & Sons. (#647)

WORMELL, R. L. *New Fibres from Proteins.* 1954 208 pp $5.80 Academic Press, Inc. (#648)

TEXTILES

HARTSUCH, BRUCE E. *Introduction to Textile Chemistry.* 1950 413 pp $4.75 John Wiley & Sons. (#649)

HARTSUCH, BRUCE E. *Textile Chemistry in the Laboratory.* 1950 75 pp $2.00 John Wiley & Sons. (#650)

HEYN, A. N. J. *Fiber Microscopy.* 1954 396 pp $5.50 Interscience Publishers, Inc. (#651)

KASWELL, E. R. *Textile Fibers, Yarns & Fabrics.* 1953 568 pp $11.00 Reinhold Publishing Corp. (#652)

MATTHEWS, J. MERRITT, and MAUERSBERGER, HERBERT R. *Textile Fibers: Their Physical, Microscopic, and Chemical Properties.* 6th Edition 1954 1283 pp $16.50 John Wiley & Sons. (#653)

MONCRIEFF, R. W. *Wool Shrinkage and Its Prevention.* 1st Amer. Edition 1954 576 pp $10.50 Chemical Publishing Co., Inc. (#654)

SPEEL, HENRY C. *Textile Chemicals and Auxiliaries.* 1952 505 pp $10.00 Reinhold Publishing Corp. (#655)

VENKATARAMAN, K. *The Chemistry of Synthetic Dyes.* Volume I 1952 704 pp $15.00 Academic Press, Inc. (#656)

VENKATARAMAN, K. *The Chemistry of Synthetic Dyes.* Volume II 1952 737 pp $15.00 Academic Press, Inc. (#657)

PETROLEUM

BEERSTECHER, E. *Petroleum Microbiology.* 1954 Approx 384 pp $8.00 Elsevier Press. (#658)

NELSON. *Petroleum Refinery Engineering.* 3rd Edition 1949 830 pp $10.50 McGraw-Hill. (#659)

SYMPOSIUM. *Agricultural Applications of Petroleum Products.* 1952 105 pp $1.50 American Chemical Society. (#660)

SYMPOSIUM. *Progress in Petroleum Technology.* 1951 393 pp $3.00 American Chemical Society. (#661)

UREN, L. C. *Petroleum Production Engineering—Oil Field Development.* 3rd Edition 1946 764 pp $9.00 McGraw-Hill. (#662)

UREN, L. C. *Petroleum Production Engineering—Oil Field Exploitation.* 3rd Edition 1953 807 pp $10.00 McGraw-Hill. (#663)

UREN, L. C. *Petroleum Production Engineering—Petroleum Production Economics.* 1950 639 pp $8.00 McGraw-Hill. (#664)

VAN NES, K., and VAN WESTEN, H. A. *Aspects of the Constitution of Mineral Oils.* 1951 484 pp $9.00 Elsevier Press. (#665)

METALLURGY

BARKSDALE, JELKS. *Titanium: Its Occurrence, Chemistry and Technology.* 1949 591 pp $12.00 The Ronald Press Company. (#666)

BRICK and PHILLIPS. *Structure and Properties of Alloys.* 2nd Edition 1949 485 pp $7.50 McGraw-Hill. (#667)

BUTTS, ALLISON. *Copper: The Science and Technology of the Metal, Its Alloys and Compounds.* 1954 832 pp $20.00 Reinhold Publishing Corp. (#668)

CLARK, DONALD S., and VARNEY, WILBUR R. *Physical Metallurgy for Engineers.* 1952 567 pp $6.50 D. Van Nostrand Company, Inc. (#669)

DEAN, REGINALD S. *Electrolytic Manganese and Its Alloys.* 1952 257 pp $12.00 The Ronald Press Company. (#670)

EVERHART, J. *Titanium and Titanium Alloys.* 1954 184 pp $3.00 Reinhold Publishing Corp. (#671)

HAYWARD, CARLE R. *Outline of Metallurgical Practice.* 3rd Edition. 1952 728 pp College Edition, $7.50 Reference Edition, $10.00 D. Van Nostrand Company, Inc. (#672)

JOHNSTONE, SYDNEY J. *Minerals for the Chemical and Allied Industries.* 1954 692 pp $11.50 John Wiley & Sons. (#673)

KUBASCHEWSKI, OSWALD, and HOPKINS, B. E. *Oxidation of Metals and Alloys.* 1953 239 pp $6.00 Academic Press, Inc. (#674)

LIDDELL. *Handbook of Nonferrous Metallurgy.* 2nd Edition In two volumes Volume I 1945 656 pp $8.50 McGraw-Hill. (#675)

LIDDELL. *Handbook of Nonferrous Metallurgy* 2nd Edition. In two volumes Volume II 1945 721 pp $9.50 McGraw-Hill. (#676)

MILLER, G. L. *Zirconium.* 1954 382 pp $7.50 Academic Press, Inc. (#677)

NININGER, ROBERT D. *Minerals for Atomic Energy.* 1954 448 pp About $7.50 D. Van Nostrand Company, Inc. (#678)

SAMANS, CARL H. *Engineering Metals and Their Alloys.* 1949 913 pp $8.00 The Macmillan Company. (#679)

SCHWARZKOPF, PAUL. *Powder Metallurgy.* 1949 379 pp $3.40 The Macmillan Company. (#680)

SCHWARZKOPF, PAUL. *Refractory Hard Metals.* 1953 447 pp $10.00 The Macmillan Company. (#681)

SHRAGER, ARTHUR M. *Elementary Metallurgy and Metallography.* 1949 297 pp $3.00 The Macmillan Company. (#682)

SKINNER, GORDON, JOHNSTON, HERRICK L., and BECKETT, CHARLES. *Titanium and Its Compounds.* 1954 174 pp $5.00 Herrick L. Johnston Enterprises. (#683)

SMITH, G. V. *Properties of Metals at Elevated Temperatures.* 1950 401 pp $8.50 McGraw-Hill. (#684)

SULLY, A. H. *Chromium.* 1954 272 pp $5.50 Academic Press, Inc. (#685)

UHLIG, H. H. *Corrosion Handbook.* 1948 1188 pp $15.00 John Wiley & Sons. (#686)

CHEMICAL ECONOMICS

ARIES, R. S., and ASSOCIATES. *Marketing Research in the Chemical Industry.* 1954 56 pp Paperbound $1.00 Chemonomics, Inc. (#687)

TYLER. *Chemical Engineering Economics.* 3rd Edition 1948 322 pp $5.00 McGraw-Hill. (#688)

ULLMANN, JOHN E. *Case Studies in Commercial Chemical Development.* 1953 127 pp Paperbound $5.00 Chemonomics, Inc. (#689)

BIOCHEMISTRY

ALBERT, ADRIAN. *Selective Toxicity with Special Reference to Chemotherapy.* 1951 228 pp $1.75 John Wiley & Sons. (#690)

ALBRITTON, ERRETT C. *Standard Values in Blood.* 1952 199 pp $4.50 W. B. Saunders Company (#691)

ANSON, M. L., BAILEY, K., and EDSALL, J. T., Editors. *Advances in Protein Chemistry.* Volume VIII 1953 529 pp $10.50 Academic Press, Inc. (#692)

AUDUS, L. J. *Plant Growth Substances.* 1953 456 pp $6.50 Interscience Publishers, Inc. (#693)

BALL, ERIC G., Editor ET AL. *Biochemical Preparations.* Volume II 1952 109 pp $3.00 John Wiley & Sons. (#694)

BARTH, L. G., and BARTH, L. J. *The Energetics of Development: A Study of Metabolism in the Frog Egg.* 1954 144 pp $3.00 Columbia University Press. (#695)

BAWDEN, F. C. *Plant Viruses and Virus Diseases.* 3rd Edition 1950 336 pp $6.00 Chronica Botanica Co. (#696)

Biochimica et Biophysica Acta. Vol. XIII Issues 5 and 6 Subscription price per volume $12.00 Monthly Journal 1954 Elsevier Press. (#697)

Leading Holt Texts in Chemistry

A new text in:

ORGANIC CHEMISTRY

By LAWRENCE H. AMUNDSEN. Designed for the one-semester course, this new book is concise, practical, and clearly written. It emphasizes basic principles, fundamentals, and theories, and also examines the most recent developments in its field. Illustrated, with questions and exercises. $4.75

Revised Editions:

GENERAL CHEMISTRY

By PIERCE W. SELWOOD. A readable and thorough text for the standard introductory course, now brought entirely up to date. $6.00

Experiments in General Chemistry $2.75

GENERAL COLLEGE CHEMISTRY

By ANDREW J. SCARLETT and JOSE GOMEZ-IBANEZ. Entirely reorganized and rewritten, with greater attention given to modern chemistry. $6.00

Laboratory Manual $2.75

QUALITATIVE ANALYSIS AND CHEMICAL EQUILIBRIUM

By THORFIN R. HOGNESS and WARREN C. JOHNSON. A sound and lucid standard text, now revised to insure modern treatment throughout. $5.00

Ionic Equilibrium as Applied to Qualitative Analysis supplies the theoretical material separately. $3.90

HENRY HOLT & CO.
383 Madison Ave., N.Y. 17

The Structures and Reactions of the Aromatic Compounds

By G. M. Badger

THE first book to be devoted to the fundamental properties of the aromatic compounds as a whole. The experimental and theoretical attempts to explain the structure of aromatic compounds are described. The characteristic properties and the mechanism of their reactions are discussed.

Since nearly all dyestuffs are 'aromatic,' as are most of the common drugs and explosives, research chemists in these industries will find the book very valuable.

$11.50 through your bookstore

CAMBRIDGE UNIVERSITY PRESS
32 East 57th Street
New York 22, N. Y.

EXPERIMENTAL INORGANIC CHEMISTRY

By W. G. Palmer

DR Palmer's book presents a laboratory course of inorganic syntheses against a background discussion of the relevant theoretical aspects of the subject.

A wide range of experiments is described, all of which are suitable for university courses, and are the direct outcome of Dr Palmer's long teaching experience.

Different from the usual text-book approach to experimental inorganic chemistry, this book will interest all those who are familiar with Dr Palmer's earlier books, as well as others.

$9.00 through your bookstore

CAMBRIDGE UNIVERSITY PRESS
32 East 57th Street, New York 22, N. Y.

BIOCHEMICAL SOCIETY SYMPOSIA No. 11 *Biological Transformation of Starch and Cellulose.* 1953 84 pp $2.25 Cambridge University Press. (#698)

BIOCHEMICAL SOCIETY SYMPOSIA No. 10. *Immunochemistry.* 1953 94 pp $2.75 Cambridge University Press. (#699)

BOREK, E. *Man, The Chemical Machine.* 1952 232 pp $3.00 Columbia University Press. (#700)

BOURNE, GEOFFREY HOWARD, and KIDDER, GEORGE W., Editors. *Biochemistry and Physiology of Nutrition.* Volume I 1953 569 pp $13.00 Academic Press, Inc. (#701)

BOURNE, G. H., and DANIELLI, J. F., Editors. *International Review of Cytology.* Volume III 1954 000 pp $00.00 Academic Press, Inc. (#702)

BOURNE, G. H., and KIDDER, G. W., Editors. *Biochemistry and Physiology of Nutrition.* Volume II 1954 641 pp $15.00 Academic Press, Inc. (#703)

BULL, HENRY B. *Physical Biochemistry.* 2nd Edition 1951 355 pp $6.00 John Wiley & Sons. (#704)

BURK, DEAN, Editor. *Cell Chemistry.* 1953 362 pp $7.50 Elsevier Press. (#705)

CANTAROW, ABRAHAM, and SCHEPARTZ, BERNARD. *Biochemistry.* 1954 848 pp $11.00 W. B. Saunders Company. (#706)

CANTAROW, ABRAHAM, and TRUMPER, MAX. *Clinical Biochemistry.* 4th Edition 1949 642 pp $8.00 W. B. Saunders Company. (#707)

CARTER, H. E. *Biochemical Preparations.* Volume I 1949 76 pp $3.00 John Wiley & Sons. (#708)

CIBA FOUNDATION SYMPOSIA. *Chemical Structure of Proteins.* 1954 208 pp $6.00 Little, Brown & Company. (#709)

DANIELLI, J. F. *Cytochemistry: A Critical Approach.* 1953 137 pp $4.00 John Wiley & Sons. (#710)

DAVIDSON, J. N. *The Biochemistry of the Nucleic Acids.* 2nd Edition 1954 200 pp $2.25 John Wiley & Sons. (#711)

DOBRINER, KONRAD, KATZENELLENBOGEN, E. R., and JONES, R. NORMAN. *Infrared Absorption Spectra of Steroids.* 1953 308 spectra 645 pp $11.50 Interscience Publishers, Inc. (#712)

DUNN and DRELL. *Experiments in Biochemistry.* 1951 216 pp $5.00 McGraw-Hill. (#713)

DU VIGNEAUD, VINCENT. *A Trail of Research in Sulfur Chemistry and Metabolism and Related Fields.* 1952 204 pp $3.25. Cornell University Press. (#714)

FISHER. *Protein Metabolism* (Methuen Biochemical Series) 1954 208 pp $00.00 John Wiley & Sons. (#715)

FISTER, HAROLD J. *Manual of Standardized Procedures for Spectrophotometric Chemistry.* 1950 728 pp $30.00 Standard Scientific Supply Corp. (#716)

FOGG, G. E. *The Metabolism of Algae.* 1953 149 pp $2.00 John Wiley & Sons. (#717)

FOX, DENIS L. *Animal Biochromes and Structural Colours.* 1953 378 pp $11.00 Cambridge University Press. (#718)

FREY-WYSSLING, A. *Submicroscopic Morphology of Protoplasm.* 2nd Edition 1953 412 pp $8.50 Elsevier. (#719)

FRUTON, JOSEPH S., and SIMMONDS, SOFIA. *General Biochemistry.* 1953 940 pp $10.00 John Wiley & Sons. (#720)

FRY. *The Nitrogen Metabolism of Micro-Organisms.* (Methuen Biochemical Series) 1954 000 pp $00.00 John Wiley & Sons. (#721)

GERO, ALEXANDER. *Biological Chemistry* (An Introduction to Biochemistry) 1952 380 pp $5.00 The Blakiston Co., Inc. (#722)

GLASCOCK, R. F. *Isotopic Gas Analysis for Biochemists.* 1954 000 pp $00.00 Academic Press, Inc. (#723)

GOODWIN, T. W. *Carotenoids—Their Comparative Biochemistry.* 1st Amer. Edition. 1954 356 pp $7.00 Chemical Publishing Co., Inc. (#724)

GORTNER, R. A., JR., and GORTNER, W. A. *Outlines of Biochemistry.* 3rd Edition 1949 1078 pp $9.00 John Wiley & Sons. (#725)

GREENBERG, D. M., Editor. *Chemical Pathways of Metabolism.* Volume I 1954 460 pp $11.00 Academic Press, Inc. (#726)

GREENBERG, D. M., Editor. *Chemical Pathways of Metabolism.* Volume II 1954 383 pp About $10.00 Academic Press, Inc. (#727)

GREENSTEIN, J. P. *Biochemistry of Cancer.* 2nd Edition 1954 653 pp $12.00 Academic Press, Inc. (#728)

GREENSTEIN, J. P., and HADDOW, A., Editors. *Advances in Cancer Research.* Volume II 1954 532 pp $11.00 Academic Press, Inc. (#729)

GURD, F. R. N., Editor. *Chemical Specificity in Biological Interactions.* 1954 000 pp $00.00 Academic Press, Inc. (#730)

HALDANE, J. B. S. *Biochemistry of Genetics.* 1954 144 pp $2.75 The Macmillan Company. (#731)

HARRIS, R. J. C., Editor. *Biological Applications of Freezing and Drying.* 1954 415 pp $10.00 Academic Press, Inc. (#732)

HARRIS, R. S., MARRIAN, G. F., and THIMANN, K. W., Editors. *Vitamins and Hormones.* Volume XI 1953 356 pp $8.50 Academic Press, Inc. (#733)

HARROW, BENJAMIN. *Laboratory Manual of Biochemistry.* 3rd Edition 1950 149 pp $2.50 W. B. Saunders Company. (#734)

HARROW, BENJAMIN, and MAZUR, ABRAHAM. *Textbook of Biochemistry.* 6th Edition 1954 563 pp $6.50 W. B. Saunders Company. (#735)

HAWK, PHILIP B., OSER, BERNARD L., SUMMERSON, WILLIAM H. *Practical Physiological Chemistry.* 13th Edition 1954 Approx 1500 pp $12.00 The Blakiston Co., Inc. (#736)

HILLER, ALMA. *Practical Clinical Chemistry.* First Edition 1953 279 pp $6.50 Charles C Thomas, Publisher (#737)

HOLLINGER, NELL F. *Practical Clinical Chemistry.* Part 1—Principles Part 2—Notes on Methods Part 3—Solutions and Reagents. 1952 Part 1—77 pp Part 2—60 Cards Part 3—93 Cards $4.50 The National Press. (#738)

KERTESZ, Z. I. *The Pectic Substances.* 1951 644 pp $15.50 Interscience Publishers, Inc. (#739)

KLEINER, ISRAEL S. *Human Biochemistry.* 4th Edition 1954 00 pp 00.00 The C. V. Mosby Company. (#740)

KLEINER, ISRAEL S., and DOTTI, LOUIS B. *Laboratory Instructions in Biochemistry.* 4th Edition 1954 000 pp $00.00 The C. V. Mosby Company. (#741)

LAIDLER, K. J. *Introduction to the Chemistry of Enzymes.* 1954 $5.00 McGraw-Hill. (#742)

LUCK, J. M., LORING, H., and MACKINNEY, G., Editors. *Annual Review of Biochemistry.* Volume XXIII 1954 650 pp $7.00 Annual Reviews, Inc. (#743)

MANN. *The Biochemistry of Semen.* (Methuen Biochemical Series) 1954 000 pp $00.00 John Wiley & Sons. (#744)

MARTIN, GUSTAV J. *Biological Antagonism.* 1951 516 pp $8.50 The Blakiston Co., Inc. (#745)

MITCHELL, P. H. *Textbook of Biochemistry.* 1950 695 pp $7.50 McGraw-Hill. (#746)

NEURATH, HANS, and BAILEY, KENNETH, Editors. *The Proteins: Chemistry, Biological Activity and Methods.* Volume I, Part A 1953 548 pp $12.00 Academic Press, Inc. (#747)

NEURATH, HANS, and BAILEY, KENNETH, Editors. *The Proteins: Chemistry, Biological Activity, and Methods.* Volume I, Part B 1953 567 pp $13.00 Academic Press, Inc. (#748)

NEURATH, HANS, and BAILEY, KENNETH, Editors. *The Proteins: Chemistry, Biological Activity, and Methods.* Volume II, Part A 1954 661 pp $14.00 Academic Press, Inc. (#749)

NORD, F. F., Editor. *Advances in Enzymology.* Volume XV 1954 557 pp $11.00 Interscience Publishers, Inc. (#750)

PERCIVAL, E. G. V. *Structural Carbohydrate Chemistry.* 1950 256 pp $6.00 Prentice-Hall Inc. (#751)

PETERSON, WILLIAM, and STRONG, F. M. *General Biochemistry.* 1953 469 pp $6.50 Prentice-Hall, Inc. (#752)

PINCUS, G., Editor. *Recent Progress in Hormone Research.* Volume X 1954 000 pp $00.00 Academic Press, Inc. (#753)

RAWLINS, T. E., and TAKAHASHI, WILLIAM N. *Technics of Plant Histochemistry and Virology.* 1952 125 pp $3.50 The National Press. (#754)

ROBINSON, F. A. *The Vitamin B. Complex.* 1951 688 pp $10.00 John Wiley & Sons. (#755)

SCHRADER, F. *Mitosis, The Movements of Chromosomes in Cell Division.* 2nd Edition 1953 164 pp $4.00 (Columbia Biological Series No. 14) Columbia University Press. (#756)

SEBRELL, WILLIAM HENRY, and HARRIS, ROBERT S., Editors. *The Vitamins: Chemistry, Physiology, Pathology.* Volume I 1954 676 pp $16.50 Academic Press, Inc. (#757)

SEXTON, W. A. *Chemical Constitution and Biological Activity.* 2nd Edition 1953 412 pp $10.00 D. Van Nostrand Company, Inc. (#758)

SMITH, G. *An Introduction to Industrial Mycology.* 4th Edition 1954 Revised 271 pp $5.00 St. Martin's Press. (#759)

SMITH, K. M., and LAUFFER, M. A., Editors. *Advances in Virus Research.* Volume I 1953 362 pp $8.00 Academic Press, Inc. (#760)

SNELL, ESMOND E., Editor ET AL. *Biochemical Preparations.* Volume III 1953 128 pp $3.50 John Wiley & Sons. (#761)

STEWART, C. P., and DUNLOP, D. M. *Clinical Chemistry in Practical Medicine.* 2nd Edition 1954 335 pp $5.00 Williams & Wilkins Co. (#762)

TAUBER, H. *Chemistry and Technology of Enzymes.* 1949 550 pp $9.50 John Wiley & Sons. (#763)

TODD, JAMES CAMPBELL, SANFORD, ARTHUR HAWLEY, and WELLS, BENJAMIN B. *Clinical Diagnosis by Laboratory Methods.* 12th Edition 1953 998 pp $8.50 W. B. Saunders Company. (#764)

TULLIS, J. L., Editor. *Blood Cells and Plasma Proteins: Their State in Nature.* 1953 436 pp $8.50 Academic Press, Inc. (#765)

WALKER, BURNHAM S., BOYD, WILLIAM C., and ASIMOV, ISAAC. *Biochemistry and Human Metabolism.* 2nd Edition 1954 900 pp Williams & Wilkins Co. (#766)

WEST, EDWARD S., and TODD, WILBERT R. *Textbook of Biochemistry.* 1951 1345 pp $12.00 The Macmillan Company. (#767)

see these

HEATH texts at the Combined Book Exhibit

L. F. Fieser
EXPERIMENTS IN ORGANIC CHEMISTRY, SECOND EDITION
498 pages $4.25

Part I, for the first course. 305 pp. $3.25. Part II, for advanced students whether or not they have used Part I. 199 pp. $2.25. Complete, 498 pp. $4.25.

L. F. Fieser and M. Fieser
ORGANIC CHEMISTRY, SECOND EDITION
1140 pages $8.00

"A wonderful book." "A tremendous book." "The finest one-volume treatment of organic chemistry in the English language." Extravagant claims? No, words straight from teachers who have used the book.

J. W. McBain
COLLOID SCIENCE
458 pages $6.75

L. F. Fieser and M. Fieser
TEXTBOOK OF ORGANIC CHEMISTRY
749 pages $7.00

A brief text for the one year course, providing a solid foundation of fundamental fact and theory. Unique chapter summaries and problems.

B S. Hopkins and J. C. Bailar
GENERAL CHEMISTRY FOR COLLEGES, FOURTH EDITION
704 pages $6.00

Content stresses the importance of chemistry in modern life. With laboratory manual, *Laboratory and Classroom Exercises in General Chemistry, 6th ed.*, by Hopkins, Moeller, and Tamres.

William C. Oelke
SEMIMICRO QUALITATIVE ANALYSIS
386 pages $4.00

D. C. HEATH AND COMPANY

SALES OFFICES: New York 14, Chicago 16, San Francisco 5, Atlanta 3, Dallas 1 HOME OFFICE: Boston 16

Houghton Mifflin 1954 Publications Feature

A fresh approach

EDWIN C. MARKHAM • SHERMAN E. SMITH

General Chemistry

. . . discusses matter in bulk and the kinetic molecular theory as background for atomic structure. Emphasizes structural chemistry in text and illustrations. Stresses practical applications.

A new laboratory manual

EDWIN C. MARKHAM • CHARLES N. REILLEY

Laboratory Manual for General Chemistry

. . . reflects the approach of the Markham-Smith *General Chemistry* and includes over 100 functional illustrations.

A thorough revision

L. P. EBLIN • D. R. CLIPPINGER • J. R. MORTON

A Laboratory Program for General Chemistry SECOND EDITION

. . . continues as an outstanding laboratory manual for general chemistry.

WHITE, A., HANDLER, P. SMITH, E. L., and STETTEN, D. *Principles of Biochemistry.* 1954 McGraw-Hill. (#768)

WHITE, PHILIP R. *The Cultivation of Animal and Plant Cells.* 1954 239 pp $6.00 The Ronald Press Company. (#769)

WHITTINGHAN and HILL. *Photosynthesis.* (Methuen Series on Biochemical Subjects) 1954 150 pp $00.00 John Wiley & Sons. (#770)

WILLIAMS, ROGER J., and BEERSTECHER, E., JR. *Introduction to Biochemistry.* 2nd Edition 1948 736 pp $6.50 D. Van Nostrand Company, Inc. (#771)

WILLIAMS, R. T. *Detoxication Mechanisms.* 1948 288 pp $5.00 John Wiley & Sons. (#772)

WOOLLEY, D. W. *A Study of Antimetabolites.* 1952 269 pp $6.50 John Wiley & Sons. (#773)

WOLSTENHOLME, G. E. W. *Isotopes in Biochemistry.* 1952 288 pp $5.00 The Blakiston Co., Inc. (#774)

BIOPHYSICS

BUTLER, J. A. V., and RANDALL, J. T., Editors. *Progress in Biophysics and Biophysical Chemistry.* Volume IV 1954 339 pp $9.50 Academic Press, Inc. (#775)

HOLLAENDER, A., Editor. *Radiation Biology.* Volume I (Two parts—not sold separately) 1954 1265 pp $17.50 McGraw-Hill. (#776)

LAWRENCE, J. H., and TOBIAS, C. A., Editors. *Advances in Biological and Medical Physics.* Volume III 1953 368 pp $8.00 Academic Press, Inc. (#777)

POLLARD, ERNEST CHARLES. *The Physics of Viruses.* 1953 230 pp $5.50 Academic Press, Inc. (#778)

BACTERIOLOGY AND PHYSIOLOGY

ANDERSON, ARTHUR K. *Essentials of Physiological Chemistry.* 4th Edition 1953 480 pp $5.00 John Wiley & Sons. (#779)

ANDERSON, A. K. *Laboratory Experiments in Physiological Chemistry.* 2nd Edition 1954 175 pp $00.00 John Wiley & Sons. (#780)

ARNOW, EARLE L., and D'ANDREA, MARIE C. *Introduction to Physiological and Pathological Chemistry.* 4th Edition 1953 503 pp $3.75 The C. V. Mosby Company. (#781)

BELL, GEORGE H., DAVIDSON, J. NORMAN, and SCARBOROUGH, HAROLD. *Textbook of Physiology and Biochemistry.* 2nd Edition 1953 1024 pp $10.00 Williams & Wilkins Co. (#782)

BEST, CHARLES HERBERT, and TAYLOR, NORMAN BURKE. *Physiological Basis of Medical Practice.* 5th Edition 1950 1343 pp $11.00 Williams & Wilkins Co. (#783)

BURNE, GEOFFREY H. *An Introduction to Functional Histology.* 1953 250 pp $5.00 Little, Brown & Company. (#784)

CIBA FOUNDATION SYMPOSIA. (Volume V—*Bioassay of Anterior Pituitary and Adrenocortical Hormones*) 1953 242 pp $6.00 Little, Brown & Company. (#785)

CIBA FOUNDATION SYMPOSIA. *Mammalian Germ Cells.* 1954 295 pp $6.75 Little, Brown & Company. (#786)

CIBA FOUNDATION SYMPOSIA. *Preservation and Transplantation of Normal Tissues.* 1954 236 pp $6.00 Little, Brown & Company. (#787)

GRAY, C. H. *The Bile Pigments.* 1953 142 pp $1.75 John Wiley & Sons. (#788)

LURIA, S. E. *General Virology.* 1953 427 pp $8.50 John Wiley & Sons. (#789)

PEARSE, A. G. E. *Histochemistry.* 1953 530 pp $12.00 Little, Brown & Company. (#790)

SCHEER, BRADLEY T. *General Physiology.* 1953 614 pp $7.00 John Wiley & Sons. (#791)

WORLD HEALTH ORGANIZATION. *BCG Vaccination,* by L. B. Edwards, C. E. Palmer, and K. Magnus. 1953 307 pp Paper: $3.00 Columbia University Press. (#792)

MICROBIOLOGY

CLIFTON, C. E., RAFFEL, S., and BARKER, H. A., Editors. *Annual Review of Microbiology.* Volume VII 505 pp $7.00 Annual Reviews, Inc. (#793)

GAINEY, P. L., and LORD, THOMAS. *Microbiology of Water and Sewage.* 1952 430 pp $5.90 Prentice-Hall, Inc. (#794)

MCCARTY, M., Editor. *Streptococcal Infections.* 1954 212 pp $5.00 (Symposia of the Section on Microbiology of the New York Academy of Medicine No. 7) Columbia University Press. (#795)

PAPPENHEIMER, JR., A. M., Editor. *The Nature and Significance of the Antibody Response.* 1953 237 pp $5.00 Columbia University Press. (#796)

SCHWARTZMAN, G. *The Effect of ACTH and Cortisone upon Infection and Resistance.* 1953 216 pp $5.00 (New York Academy of Medicine, March 1952, Section on Microbiology, Symposium No. 6) Columbia University Press. (#797)

WAKSMAN, SELMAN A. *Soil Microbiology.* 1952 356 pp $6.00 John Wiley & Sons. (#798)

PHARMACEUTICAL

BELLAFIORE, IGNATIUS J. *Pharmaceutical Arithmetic.* 3rd Edition 1953 236 pp $4.50 The C. V. Mosby Company. (#799)

BURGER, ALFRED. *Medicinal Chemistry: Chemistry, Biochemistry, Therapeutic and Pharmacological Action of Natural and Synthetic Drugs.* (In two volumes) Vol. I 1951 595 pp $11.50 Interscience Publishers, Inc. (#800)

BURGER, ALFRED. *Medicinal Chemistry: Chemistry, Biochemistry, Therapeutic and Pharmacological Action of Natural and Synthetic Drugs.* (In two volumes) Vol. II 1951 522 pp $11.50 Interscience Publishers, Inc. (#801)

COLLIER, H. O. J. *Chemotherapy of Infections.* 1954 248 pp $4.00 John Wiley & Sons. (#802)

COOK, E. FULLERTON, BEAL, GEORGE D., ET AL. *The Pharmacopeia of the United States of America.* 14th Edition Revised 1950 1067 pp $9.00 Mack Publishing Co. (#803)

COOK, E. FULLERTON, and MARTIN, ERIC W. *Remington's Practice of Pharmacy.* 10th Edition 1950 1630 pp $16.00 Mack Publishing Co. (#804)

FINDLAY, G. M. *Recent Advances in Chemotherapy.* 3rd Edition Volume I 1950 625 pp $7.50 The Blakiston Co., Inc. (#805)

FINDLAY, G. M. *Recent Advances in Chemotherapy.* 3rd Edition (Volume II—Malaria) 1951 597 pp $7.50 The Blakiston Co., Inc. (#806)

FINDLAY, G. M. *Recent Advances in Chemotherapy.* 3rd Edition (Volume III—Antibiotics) 1954 293 pp $6.50 The Blakiston Co., Inc. (#807)

JENKINS, C. L., and HARTUNG, W. H. *The Chemistry of Organic Medicinal Products.* 3rd Edition 1949 745 pp $7.50 John Wiley & Sons. (#808)

MERCK & CO., INC. *The Merck Manual—a handbook of diagnosis, treatment, and materia medica.* 1592 pp $5.00 plain $5.50 thumb-index Merck & Co., Inc. (#809)

POWERS, JUSTIN L., SCHAEFER, HUGO H., ET AL. *The National Formulary.* 9th Edition 877 pp $8.00 Mack Publishing Co. (#810)

STOCKING, CHARLES H., and CATALINE, ELMON L. *Steven's Arithmetic of Pharmacy.* 8th Edition. 1952 148 pp $2.75 D. Van Nostrand Company, Inc. (#811)

SUTER, C. M., Editor, ET AL. *Medicinal Chemistry: A Series of Reviews Prepared under the Auspices of the Division of Medicinal Chemistry of the A C S.* Volume I 1951 473 pp $10.00 John Wiley & Sons. (#812)

FOODS AND NUTRITION

JACOBS, MORRIS B. *Chemical Analysis of Foods and Food Products.* 2nd Edition 1951 904 pp $10.00 D. Van Nostrand Company, Inc. (#813)

JACOBS, MORRIS B. *The Chemistry and Technology of Food and Food Products.* 2nd Edition Revised and augmented In three volumes Volume I 1951 857 pp $15.00 Interscience Publishers, Inc. (#814)

JACOBS, MORRIS B. *The Chemistry and Technology of Food and Food Products.* 2nd Edition Revised and augmented In three volumes Volume II 1951 960 pp $18.00 Interscience Publishers, Inc. (#815)

JACOBS, MORRIS B. *The Chemistry and Technology of Food and Food Products.* 2nd Edition Revised and augmented In three volumes Volume III 1951 837 pp $18.00 Interscience Publishers, Inc. (#816)

MONIER-WILLIAMS, C. W. *Trace Elements in Food.* 1949 511 pp $6.00 John Wiley & Sons. (#817)

MRAK, E. M., and STEWART, G. F., Editors. *Advances in Food Research.* Volume IV 1953 420 pp $9.00 Academic Press, Inc. (#818)

PROUDFIT, FAIRFAX T., and ROBINSON, CORRINE H. *Nutrition and Diet Therapy.* 10th Edition 1950 951 pp $4.50 The Macmillan Company. (#819)

SHERMAN, HENRY C. *Chemistry of Foods and Nutrition.* 8th Edition 1952 636 pp $6.00 The Macmillan Company. (#820)

WOODMAN. *Food Analysis.* 4th Edition 1941 607 pp $8.50 McGraw-Hill. (#821)

AGRICULTURAL CHEMISTRY

BRAULTECHT, CHARLES A. *Starch, Its Source, Production, and Uses.* 1953 408 pp $10.00 Reinhold Publishing Corporation. (#822)

Karol J. Mysels
Charles S. Copeland

INTRODUCTION TO THE SCIENCE OF CHEMISTRY

This introductory course in chemistry covers the topics normally treated but has a new organization which leads the student from the simple to the complicated with a solid basis for each successive step. Diagrams and graphical presentations are utilized more than is customary. There is an excellent laboratory manual to accompany the text.

Alfred B. Garrett
Joseph F. Haskins
Harry H. Sisler

ESSENTIALS OF CHEMISTRY

An abundance of applications and illustrations plus a readable style make this text a popular one with students. Its organization is based on the various phases of our physical environment. The accompanying laboratory manual teaches principles, develops techniques, and has at least one experiment plus exercises for each chapter.

HOME OFFICE: BOSTON

GINN AND COMPANY SALES OFFICES: New York 11 Chicago 16
Atlanta 3 Dallas 1 Columbus 16 San Francisco 3 Toronto 7

New Books from Williams & Wilkins

KOCH and HANKE

Practical Methods in Biochemistry, 6th edition

Clear, accurate directions for over 300 laboratory experiments and for the preparation of various laboratory reagents. Interesting discussion of manometric methods with the Van Slyke-Neill apparatus. Includes microbiological methods for vitamins and amino acids, and colorimetric and fluorimetric methods.

548 pp. 28 figs. (1953) $5.00

BELL, DAVIDSON and SCARBOROUGH

Textbook of Physiology and Biochemistry, 2nd edition

Physiology and biochemistry treated as one subject, with emphasis on their relevance to clinical problems. Demonstrates the many interrelations of the subject by means of numerous cross-references. Second edition carefully revised: includes modern developments without overshadowing the older and more basic matter.

1024 pp. 604 figs. 176 pits. (1953) $10.00

WALKER, BOYD and ASIMOV

Biochemistry and Human Metabolism, 2nd edition

A biochemistry text emphasizing the clinical viewpoint. This dictates every decision of what to include and exclude. Classical order of topics altered so that proteins can be taken up first—a departure from the usual "horizontal" approach. Carbohydrate and lipid chemistry taken up as an introduction to tissue chemistry. While stressing the uncertainties, biochemistry is shown to be a growing, expanding science which can change with bewildering rapidity.

904 pp. 30 figs. (1954) $10.00

STEWART and DUNLOP

Clinical Chemistry in Practical Medicine, 4th edition

This edition almost entirely rewritten to reflect the increasing importance of biochemistry to medicine—particularly as an aid to diagnosis, prognosis and treatment of the metabolic diseases. Teaches the circumstances in which a chemical examination is useful, the technic of obtaining specimens for the laboratory, and the correct interpretation and evaluation of the results. Emphasizes the most important and reliable tests.

335 pp. 27 figs. (1954) $5.00

THE WILLIAMS & WILKINS COMPANY
Mt. Royal and Guilford Avenues Baltimore 2, Maryland

BROWN, A. W. A. *Insect Control by Chemicals.* 1951 817 pp $12.50 John Wiley & Sons. (#823)

DUTCHER, R. A., JENSEN, C. O., and ALTHOUSE, P. M. *Introduction to Agricultural Biochemistry.* 1951 502 pp $6.00 John Wiley & Sons. (#824)

FREAR, DONALD E. H. *Agricultural Chemistry.* (Volume I—Principles of Agricultural Chemistry) 1950 902 pp $9.50 D. Van Nostrand Company, Inc. (#825)

FREAR, DONALD E. H. *Agricultural Chemistry.* (Volume II—Applications of Agricultural Chemistry) 1951 588 pp $9.50 D. Van Nostrand Company, Inc. (#826)

FREAR, DONALD E. H. *Chemical Fungicides and Plant Insecticides.* 1948 154 pp $5.50 Chronica Botanica Co. (#827)

FREAR, DONALD E. H. *Chemical Insecticides.* 1947 204 pp $6.50 Chronica Botanica Co. (#828)

HOWES, F. N. *Vegetable Tanning Materials.* 1953 325 pp $5.50 Chronica Botanica Co. (#829)

JACOB, KENNETH D., Editor. *Fertilizer Technology and Resources in the United States.* 1953 454 pp $8.50 Academic Press, Inc. (#830)

PIERRE, WILLIAM HENRY, and NORMAN, A. G., Editors. *Soil and Fertilizer Phosphorus in Crop Nutrition.* 1953 492 pp $9.00 Academic Press, Inc. (#831)

SHAW, B. T., Editor. *Soil Physical Conditions and Plant Growth.* 1952 491 pp $8.80 Academic Press, Inc. (#832)

SHEPARD, H. H. *The Chemistry and Action of Insecticides.* 1951 540 pp $7.50 McGraw-Hill. (#833)

WAGGAMAN, WILLIAM. *Phosphoric Acid, Phosphates and Phosphoric Fertilizers* 2nd Edition 1952 683 pp $15.00 Reinhold Publishing Corp. (#834)

WALLACE, T., ET AL. *Trace Elements in Plant Physiology.* 1950 160 pp $4.50 Chronica Botanica Co. (#835)

HISTORY AND BIOGRAPHY

BROWNE, CHARLES ALBERT, and WEEKS, MARY ELVIRA. 75 *Eventful Years* (A History of the American Chemical Society) 1951 527 pp $5.00 American Chemical Society (#836)

FARBER, EDUARD. *The Evolution of Chemistry: A History of Its Ideas, Methods and Materials.* 1952 349 pp $6.00 The Ronald Press Company. (#837)

FINDLAY, ALEXANDER. *A Hundred Years of Chemistry.* 2nd Edition 1948 318 pp $3.25 The Macmillan Company. (#838)

GETMAN, FREDERICK H. *The Life of Ira Remsen.* 1940 157 pp $2.50 Chemical Education Publishing Co. (#839)

HAYNES, WILLIAMS. *American Chemical Industry.* In six volumes (Volume I—Background and Beginnings) 1954 482 pp $15.00 Per Set $76.00 D. Van Nostrand Company, Inc. (#840)

HAYNES, WILLIAMS. *American Chemical Industry.* In six volumes (Volumes II–III World War I Period, 1912–1922) 1945 440 pp $15.00 each D. Van Nostrand Company, Inc. (#841)

HAYNES, WILLIAMS. *American Chemical Industry.* In six volumes (Volume III—Word War I Period 1912–1922) 1945 606 pp $15.00 D. Van Nostrand Company, Inc. (#842)

HAYNES, WILLIAMS. *American Chemical Industry.* In six volumes (Volume IV—The Merger Era, 1923–1929) 1948 440 pp $15.00 D. Van Nostrand Company, Inc. (#843)

HAYNES, WILLIAMS. *American Chemical Industry.* In six volumes (Volume V—The Decade of New Products, 1930–1939) 1954 510 pp $15.00 D. Van Nostrand Company, Inc. (#844)

HAYNES, WILLIAMS. *American Chemical Industry.* In six volumes (Volume VI—Histories of the Companies) 1949 559 pp $15.00 D. Van Nostrand Company, Inc. (#845)

LEICESTER, J., and KLICKSTEIN, H. *Sourcebook in Chemistry.* 1952 545 pp $7.50 McGraw-Hill. (#846)

LI CH'IAO-P'ING. *The Chemical Arts of Old China.* 1948 215 pp $5.00 Chemical Education Publishing Co. (#847)

WEEKS, MARY ELVIRA. *Discovery of the Elements.* 5th Edition 1945 578 pp Chemical Education Publishing Co. (#848)

REPRINTS OF SCIENTIFIC PERIODICALS

Annual Review of Biochemistry. 1932 Volume I Cloth bound reprint $11.00 Johnson Reprint Corporation. (#849)

Chemical Abstracts. 1910 Volume IV Paper bound reprint in 5 parts $75.00 per volume Johnson Reprint Corporation. (#850)

Chemical Reviews. 1924 Volume I Paper bound reprint $15.00 Johnson Reprint Corporation. (#851)

Ergebnisse der Enzymforschung. 1943 Volume IX cloth bound reprint $12.50 Johnson Reprint Corporation. (#852)

Helvetica Chimica Acta. 1918 Volume I Paper bound reprint $25.00 Johnson Reprint Corporation. (#853)

Journal, Chemical Society London. 1848 Volume I Paper Bound Reprint $20.00 Johnson Reprint Corporation. (#854)

Journal of Chemical Physics. 1933 Volume I Paper bound reprint $20.00 Johnson Reprint Corporation. (#855)

Journal of Organic Chemistry. 1948 Volume XIII Paper bound reprint $20.00 Johnson Reprint Corporation. (#856)

Journal of Physical Chemistry. 1933 Volume XXXVII Paper bound reprint. $25.00 Johnson Reprint Corporation (#857)

Justus Liebigs Annalen der Chemie. Volume 542 1939 paper bound reprint $8.35 Johnson Reprint Corporation. (#858)

Pharmacological Reviews. Volume I 1939 Paper bound reprint $15.00 Johnson Reprint Corporation. (#859)

Recueil des Travaux Chimiques des Pays-Bas. 1882 Volume I Paper bound reprint $15.00 Johnson Reprint Corporation. (#860)

REFERENCE

ACS COMMITTEE ON PROFESSIONAL TRAINING. *Faculties, Publications, and Doctoral Theses—Chemistry and Chemical Engineering—United States Colleges and Universities.* 1953 256 pp $2.00 American Chemical Society. (#861)

BRIDGWATER, W., and SHERWOOD, E. J., Editors. *The Columbia Encyclopedia* (1 Volume). 2nd Edition 1950 2211 pp., with 1953 Supplement. $35.00 Columbia University Press (#862)

CALLAHAM, L. *Russian-English Technical and Chemical Dictionary.* 1947 794 pp $15.00 John Wiley & Sons. (#863)

CHEMICAL ABSTRACTS, Editors. *List of Periodicals Abstracted.* 1951 256 pp $3.00 American Chemical Society. (#864)

COLEMAN, H. S. *Laboratory Design.* 1951 398 pp $15.00 Reinhold Publishing Corporation. (#865)

DEVRIES, L. *German-English Science Dictionary.* 2nd Edition 1946 940 pp $6.50 McGraw-Hill. (#866)

DEVRIES, L. *German-English Technical and Engineering Dictionary.* 1950 940 pp $22.50 McGraw-Hill. (#867)

FOTOS, J. T., and BRAY, J. L. *German Grammar for Chemists and Other Science Students.* 1938 323 pp $3.50 John Wiley & Sons. (#867-1)

FOTOS, J. T., and BRAY, J. L. *Introductory Readings in Chemical and Technical German.* 1941 303 pp $3.50 John Wiley & Sons. (#867-2)

FOTOS, J. T., and SHREVE, R. N. *Advanced Readings in Chemical and Technical German.* 1940 304 pp $3.75 John Wiley & Sons. (#867-3)

GARDNER, WILLIAM. *Chemical Synonyms and Trade Names.* 5th Edition 1947 558 pp $15.00 D. Van Nostrand Company, Inc. (#868)

HACKH, INGO W. D., revised by GRANT, JULIUS. *Hackh's Chemical Dictionary.* 3rd Edition 1944 925 pp $9.50 The Blakiston Co., Inc. (#869)

HAYNES, WILLIAMS. *Chemical Trade Names and Commercial Synonyms.* 1951 338 pp $5.50 D. Van Nostrand Company, Inc. (#870)

HOERR, NORMAND L., OSOL, ARTHUR, CHASE, SAMUEL L., FRANCIS, CARL C., HOWELL, MARION G., and MOORE, LAURA E., Editors. *Blakiston's Illustrated Pocket Medical Dictionary.* 1952 1005 pp Plain Edition, $3.25; Thumb-indexed, $3.75 The Blakiston Co., Inc. (#871)

JACOBSON, C. A. *Encyclopedia of Chemical Reactions.* Volume V 1953 790 pp $15.00 Reinhold Publishing Corp. (#872)

JONES, HAROLD W., HOERR, NORMAND L., and OSOL, ARTHUR, Editors. *Blakiston's New Gould Medical Dictionary with 1954 Supplement.* Reprinted 1953. 1294 pp Standard Edition, fabrikoid bound, rigid or flexible cover $9.50, Professional Thin Paper Edition, rigid or flexible cover $11.00, Deluxe Edition, flexible. genuine leather binding $15.00 The Blakiston Co., Inc. (#873)

KING, ALEXANDER, and FROMHERZ, HANS. *German-English Chemical Terminology.* 2nd Edition 1951 361 pp $6.75 D. Van Nostrand Company, Inc. (#874)

LANGE, N. A. *Handbook of Chemistry.* 8th Edition 1952 1985 pp $7.00 Handbook Publishers, Inc. (#875)

MELLON, M. G. *Chemical Publications.* 2nd Edition 1940 284 pp $4.50 McGraw-Hill. (#876)

MERCK & CO., INC. *The Merck Index, an encyclopedia of drugs and chemicals.* 6th Edition 1952 1167 pp $7.50 plain, $8.00 thumb-index. Merck & Co., Inc. (#877)

PATTERSON, AUSTIN M. *A French-English Dictionary for Chemists.* 2nd Edition 1954 476 pp $6.50 John Wiley & Sons. (#878)

PATTERSON, A. M. *German-English Dictionary for Chemists.* 3rd Edition 1950 541 pp $6.00 John Wiley & Sons. (#879)

PERRY, J. W. *Chemical Russian Self-Taught.* 1948 232 pp $3.00 Chemical Education Publishing Co. (#880)

PERRY, JAMES W. *Scientific Russian.* 1951 846 pp $10.00 Interscience Publishers, Inc. (#881)

SAX, N. IRVING. *Handbook of Dangerous Materials.* 1951 850 pp $15.00 Reinhold Publishing Corporation. (#882)

SCHROCK, EDWARD M. *Quality Control and Statistical Methods.* 1950 250 pp $5.00 Reinhold Publishing Corporation. (#883)

PEARSE—

HISTOCHEMISTRY

THEORETICAL AND APPLIED

Certainly the leading selling book in a rapidly growing field. "...the biologist or biochemist desiring to explore the applicability of histochemical methods to a specific problem may well turn first to Pearse's book." *Jnl. Chem. Ed.* $12.00

HITCHCOCK'S

PHYSICAL CHEMISTRY

FOR STUDENTS OF BIOLOGY AND MEDICINE

A specific text for a specific need. Problems and laboratory experiments add to the book's usefulness. $5.00

Ciba Foundation Volumes of Special Interest

PRESERVATION AND TRANSPLANTATION OF NORMAL TISSUES	**$6.00**
CHEMICAL STRUCTURE OF PROTEINS	**6.00**
MAMMALIAN GERM CELLS	**6.75**
BIOASSAY OF ANTERIOR PITUITARY AND ADRENOCORTICAL HORMONES	**6.00**
CHEMISTRY AND BIOLOGY OF PTERIDINES	**soon**

BOSTON • LITTLE, BROWN AND COMPANY • TORONTO

Order from your Medical Bookstore or

Little, Brown & Company, 34 Beacon St., Boston 6, Mass.

Please send me:

HISTOCHEMISTRY	$12.00
PHYSICAL CHEMISTRY	5.00
PRESERVATION AND TRANSPLANTATION OF NORMAL TISSUES	6.00
CHEMICAL STRUCTURE OF PROTEINS	6.00
MAMMALIAN GERM CELLS	6.75
BIOASSAY OF ANTERIOR PITUITARY AND ADRENOCORTICAL HORMONES	6.00
CHEMISTRY AND BIOLOGY OF PTERIDINES	

Name.....

Address.....

City.....Zone....State.....

☐ Check ☐ Money Order

"Titanium and Its Compounds"

by GORDON SKINNER
HERRICK L. JOHNSTON and
CHARLES BECKETT

174 pages

A critical compilation of information in the literature on the physical and thermodynamic properties of titanium and its compounds. Included are a number of appendices listing thermal functions compiled by the authors on the basis of data taken from the literature. "Titanium and Its Compounds" also includes a complete bibliography of 553 entries.

Soft cover binding	$3.50
Hard cover binding	$5.00

Postage prepaid when check or money order accompanies the order.

JOHNSTON EQUIPMENT & SUPPLY CORP.

DEPT. J

540 West Poplar Avenue — Columbus 8, Ohio

MICROTEXT CARDS
MICROCARDS®
MICROPRINTS

NEW CARD READERS IN STOCK:

EASTMAN KODAK MICROPRINT READER
The newest and finest—nothing more versatile $300.00

MICROCARD ® READER
Precision construction—most convenient page turning operation $255.00

MICROLEX READER
Unique optical principle—beautiful image with economy $142.50

PARTIAL LISTINGS

A.C.S. OUT-OF-PRINT MONOGRAPHS
Nos. 3, 33, 37, 50, 52, 56, 58, 59, 61, 68, 72, 74, 80, 86, 93, 99.

1.	J. Biological Chemistry Vol. 1–45 (1905–1921) Index	$ 174.80
2.	Journal Fuer Praktische Chemie NS Vol. 1–162 (1870–1943) indices	396.00
3.	Z. Fuer Anorganische und Allgemeine Chemie Vol. 1–252 (1892–1944) indices	625.00
4.	Liebig's Annalen Der Chemie Vol. 1–554 (1832–1943) indices	1008.80
5.	Berichte Vol. 1–77 (1868–1945) indices	1168.00
6.	Z. Fuer Physikalische Chemie Vol. 1–193 (1887–1944); ABT. B, Vol. 1–53 (1928–1943) indices	706.80
7.	Physikalische Zeitschrift Vol. 1–43 (1900–1942)	234.50

All in Stock for Immediate Delivery

Write For Complete Catalogue

THE MICROTEXT PUBLISHING CORP.
112 Liberty Street, New York 6, N. Y. Rector 2-2057

SNELL, FOSTER D., and SNELL, CORNELIA T. *Chemicals of Commerce.* 2nd Edition 1952 587 pp $6.50 D. Van Nostrand Company, Inc. (#884)

SOULE, B. A. *Library Guide for the Chemist.* 1938 285 pp $5.00 McGraw-Hill. (#885)

Stedman's Medical Dictionary. 18th Edition 1605 pp $11.50 Williams & Wilkins Co. (#886)

STRONG, R. K. *Kingzett's Chemical Encyclopedia.* 8th Edition 1952 1186 pp $16.00 D. Van Nostrand Company, Inc. (#887)

SYMPOSIUM. *Searching the Chemical Literature.* 1951 184 pp $2.00 American Chemical Society. (#888)

Thorpe's Dictionary of Applied Chemistry. (Volume XI Soil to Zymurgy) 4th Edition 1954 925 pp $25.00 Longmans. (#889)

TURNER, FRANCIS, Editor, revised and enlarged by ARTHUR and ELIZABETH ROSE. *Condensed Chemical Dictionary.* 4th Edition 1950 760 pp $12.00 Reinhold Publishing Corporation. (#890)

Van Nostrand's Chemists' Dictionary. 1953 760 pp $10.00 D. Van Nostrand Company, Inc. (#891)

WELCHER, FRANK. *Chemical Solutions.* 1942 404 pp $5.25 D. Van Nostrand Company, Inc. (#892)

WISWESSER, WILLIAM J. *A Line-Formula Chemical Notation.* 1954 149 pp $2.00 Thomas Y. Crowell Company. (#893)

MISCELLANEOUS

Chemistry, Key to Better Living. Diamond Jubilee Volume 1951 245 pp $4.00 American Chemical Society. (#897)

GENERAL SAFETY COMMITTEE OF THE MANUFACTURING CHEMISTS' ASSOCIATION. *Guide for Safety in the Chemical Laboratory.* 1954 $4.25 D. Van Nostrand Company, Inc. (#898)

GRADY, ROY I., CHITTUM, JOHN W., ET AL. *The Chemist at Work.* 1940 422 pp $3.00 Chemical Education Publishing Co. (#899)

JUDD, DEANE B. *Color in Business, Science, and Industry.* 1952 401 pp $8.50 John Wiley & Sons. (#900)

MASON, BRIAN. *Principles of Geochemistry.* 1952 276 pp $5.50 John Wiley & Sons. (#901)

POLLACK, PHILIP. *Careers and Opportunities in Science; A Survey of All Fields.* 1954 $3.75 256 pp. E. P. Dutton & Co., Inc. (#901-1)

ROSIN, J., and EASTMAN, M. *The Road to Abundance.* 1953 166 pp $3.50 McGraw-Hill. (#902)

SYMPOSIUM. *Chemical Nomenclature.* 1953 114 pp $2.50 American Chemical Society. (#903)

THOMAS, EDWARD. *Chemical Inventions and Chemical Patents.* 1950 881 pp $16.50 Clark Boardman Co., Ltd. (#904)

WILSON, E. B., JR. *An Introduction to Scientific Research.* 1952 376 pp $6.00 McGraw-Hill. (#905)

Names and Addresses of Cooperating Publishers
CHEMICAL EDUCATION BOOK EXHIBIT

ACADEMIC PRESS, INC.
125 East 23rd St., New York 10, N. Y.

ADDISON-WESLEY PRESS, INC.
Kendall Square Bldg., Cambridge 42, Mass.

AMERICAN BOOK COMPANY
55 Fifth Ave., New York 3, N. Y.

AMERICAN CHEMICAL SOCIETY
1155 Sixteenth St., N. W., Washington 6, D. C.

ANNUAL REVIEWS, INC.
Stanford, Calif.

APPLETON-CENTURY-CROFTS, INC.
35 West 32nd St., New York 1, N. Y.

THE BLAKISTON COMPANY
575 Madison Ave., New York 22, N. Y.

CAMBRIDGE UNIVERSITY PRESS
32 East 57th St., New York 22, N. Y.

CHEMICAL EDUCATION PUBLISHING CO.
Easton, Pa.

CHEMICAL PUBLISHING CO., INC.
212 Fifth Ave., New York 10, N. Y.

CHEMONOMICS, INC.
400 Madison Ave., New York 17, N. Y.

CHRONICA BOTANICA COMPANY
Waltham 54, Mass.

CLARK-BOARDMAN CO., LTD.
11–15 Park Place, New York 7, N. Y.

COLUMBIA UNIVERSITY PRESS
Journalism Bldg., 2960 Broadway. New York 27, N. Y.

CORNELL UNIVERSITY PRESS
124 Roberts Place, Ithaca, N. Y.

THOMAS Y. CROWELL COMPANY
432 Fourth Ave., New York 16, N. Y.

DEGERING, ED F.
12 Grove St., Natick, Mass.

E. P. DUTTON & CO., INC.
300 Fourth Ave., New York 10, N. Y.

ELSEVIER PRESS, INC.
402 Lovett Blvd., Houston 6, Tex.

GINN AND COMPANY
Statler Bldg., Boston 17, Mass.

HANDBOOK PUBLISHERS, INC.
Sandusky, Ohio

HARPER & BROTHERS
49 East 33rd St., New York 16, N. Y.

HEATH AND COMPANY, D. C.
285 Columbus Ave., Boston 16, Mass.

HENRY HOLT AND COMPANY
257 Fourth Ave., New York 10, N. Y.

HERRICK L. JOHNSTON ENTERPRISES
540 West Poplar Ave., Columbus 8, Ohio

HOUGHTON MIFFLIN COMPANY
2 Park St., Boston 7, Mass.

INTERCONTINENTAL MEDICAL BOOK CORP.
381 Fourth Ave., New York 16, N. Y.

INTERSCIENCE PUBLISHERS, INC.
250 Fifth Ave., New York 1, N. Y.

JOHNSON REPRINT CORPORATION
125 East 23rd St., New York 10, N. Y.

WALTER J. JOHNSON, INC.
125 East 23rd St., New York 10, N. Y.

LITTLE, BROWN & CO.
34 Beacon St., Boston 6, Mass.

LONGMANS, GREEN & COMPANY, INC.
55 Fifth Ave., New York 3, N. Y.

THE MACMILLAN COMPANY
60 Fifth Ave., New York 11, N. Y.

MACK PUBLISHING COMPANY
Easton, Pa.

McGRAW-HILL BOOK COMPANY, INC.
330 West 42nd St., New York 36, N. Y.

MERCK & CO., INC., Publications Dept.
Rahway, N. J.

C. V. MOSBY COMPANY
3207 Washington Blvd., St. Louis 3, Mo.

NATIONAL PRESS, INC.
273 Broadway, Millbrae, Calif.

PRENTICE-HALL, INC.
70 Fifth Ave., New York 11, N. Y.

REINHOLD PUBLISHING CORPORATION
430 Park Ave., New York 22, N. Y.

RINEHART & COMPANY, INC.
232 Madison Ave., New York 16, N. Y.

THE RONALD PRESS COMPANY
15 East 26th St., New York 10, N. Y.

W. B. SAUNDERS COMPANY
West Washington Sq., Philadelphia 5, Pa.

SILVER BURDETT COMPANY
45 East 17th St., New York 3, N. Y.

STANDARD SCIENTIFIC SUPPLY CORP.
34 West 4th St., New York 12, N. Y.

ST. MARTIN'S PRESS, INC.
103 Park Ave., New York 17, N. Y.

CHARLES C THOMAS, PUBLISHER
301–327 East Lawrence Ave., Springfield, Ill.

THE UNIVERSITY OF CHICAGO PRESS
5750 Ellis Ave., Chicago, Ill.

D. VAN NOSTRAND COMPANY, INC.
250 Fourth Ave., New York 3, N. Y.

JOHN WILEY & SONS, INC.
440 Fourth Ave., New York 16, N. Y.

WILLIAMS & WILKINS COMPANY
Mt. Royal & Guilford Aves., Baltimore 2, Md.

A New International Centrifuge

FOR THE

Modern Laboratory

The new INTERNATIONAL MODEL U is more than just a Centrifuge in a cabinet. International's experienced engineering has produced a Centrifuge with years-ahead features and unmatched performance.

You will want to know more about the new aerodynamic guard bowl ventilating system—the new stainless steel interior — the stainless steel auxiliary cover that saves valuable bench space — the electric tachometer — the electric time clock — the unique air-filtering system—the spring-loaded hinge — the new vibration dampening system which results in smooth operation without the "shaker" action of over-flexible mountings — the versatility of 84 interchangeable accessory combinations.

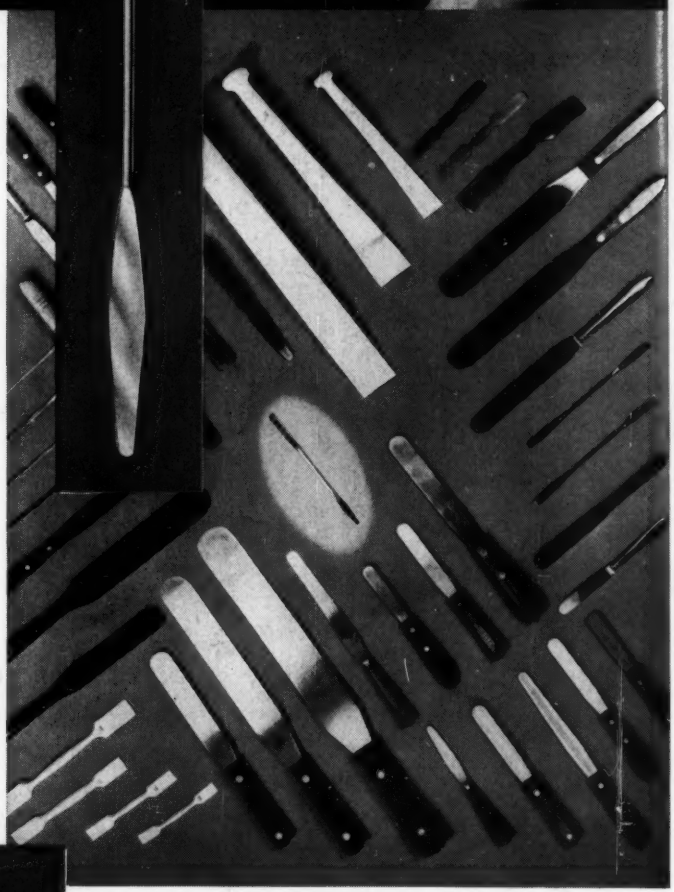
Let us tell you more about this completely new Centrifuge, handsomely designed to fit in with your wall counters and cabinets. Write for Bulletin J explaining all these features in detail.

INTERNATIONAL EQUIPMENT COMPANY

1284 SOLDIERS FIELD ROAD, BOSTON 35, MASS.

FISHER — *the one-call source for all la... supplies*

ANOTHE... FISHER "SCOOP"



This new stainless steel spatula is specially designed for the semi-micro chemist. It is non-corrosive and as smoothly functional in appearance as a surgeon's scalpel.

This is an important addition to the complete line of Spatulas offered by Fisher. Together with the large 442-millimeter pilot-plant "club" and all the sizes and shapes in-between, all are designed to answer a specific need, *best*.

This school of spatulas is typical of the vast variety of job-designed tools found on almost every page of the Fisher Catalog.

Rely on the Fisher Catalog for all your laboratory requirements.